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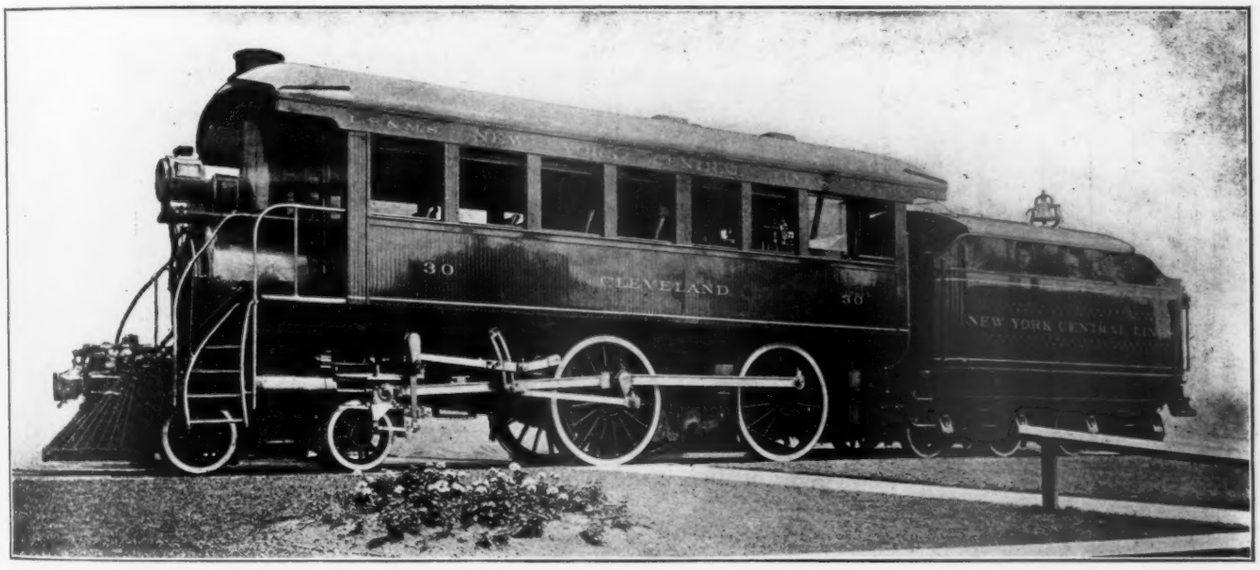
FOUR CYLINDER BALANCE SIMPLE LOCOMOTIVE.

LAKE SHORE AND MICHIGAN SOUTHERN RAILWAY.

The first four-cylinder balanced simple locomotive to be built in this country was recently finished at the Collinwood shops of the Lake Shore & Michigan Southern Railway, and has been put into service. It is an inspection engine, where the easy riding features of a balanced locomotive are particularly desirable, and was constructed after designs prepared by Mr. H. F. Ball, superintendent of motive power, and Mr. R. B. Kendig, mechanical engineer.

As can be seen in the illustration, it is of the American type with the forward or main drivers set over 13 ft. from the centre of the cylinder. There are four equal cylinders each 12½ by 20 ins. set in a horizontal line below the front end. The two outside cylinders are connected to the drivers in the usual manner and the inside cylinders drive through practically duplicate connections to the crank axle. A single piston valve with inside admission is located between and above the cylinders and is operated by a simple design of Walschaert valve gear.



FOUR CYLINDER BALANCED SIMPLE INSPECTION LOCOMOTIVE. LAKE SHORE AND MICHIGAN SOUTHERN RAILWAY.

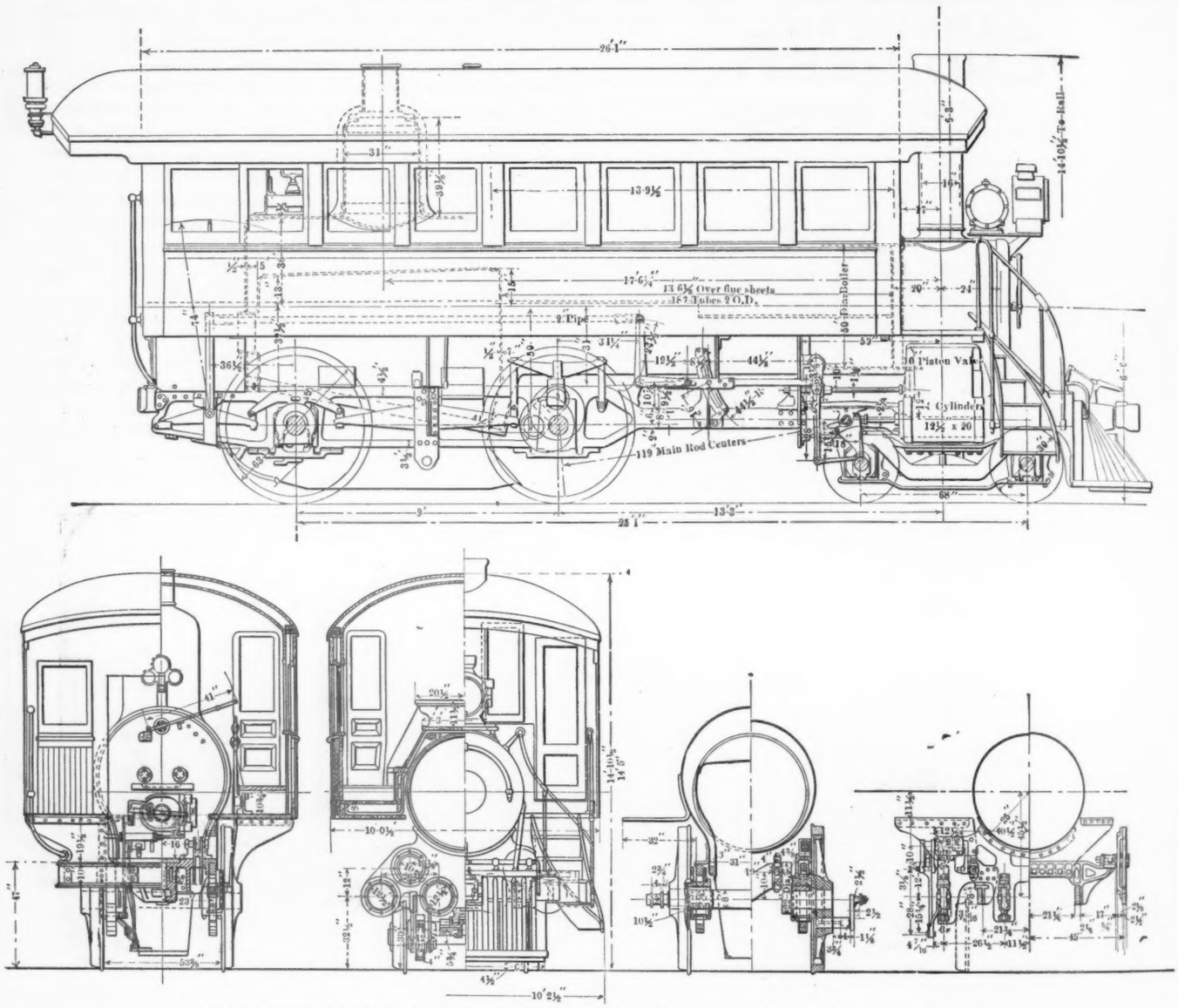
The boiler is surmounted by a large observation cab which extends from just behind the smoke stack back to and including the regular locomotive cab. The design of this cab is similar to a coach body with the regularly spaced windows and a typical coach roof. The observation room proper is 13 ft. 9½ ins. long and includes four windows on either side. Provision is made for placing four easy chairs on either side of the boiler, and there is additional room provided by a permanent seat on top of the boiler barrel at the rear wall of the observation room and by the flat section on top of the boiler, which can be used either as a seat or for chairs. The floor of the cab is raised from 6 to 12 ins. above the running board, the rear half being 6 ins. above that ahead. The heating coils are placed on either side of the boiler in the narrow runway just above the floor level, the sides of this space facing the cab are of grating and the top forms a step or foot rest. The boiler barrel is heavily lagged as is also the under section of the covering forming the seat and sides over the boiler. There is also a dead air space between the two which further insulates the cab. The windows are arranged with a balanced hanging so that they can be dropped down into the sides of the car, the sill piece being so constructed as to slide over the opening, making a smooth sill when the windows are opened and preventing rattling when closed. The front doors open to the winding steps leading forward and are arranged to swing outward so that the pressure of air while the locomotive is running tends to hold them tightly closed. An adjustable rod is provided for holding them open at any desired amount. An auxilliary engineers' valve and a system of signals to the engineer are located convenient to the front right hand chair. The interior of the cab is finished in the same excellent style seen in modern passenger coaches.

A standard type of tender is used, having in addition a covering which completely closes over the coal space, thus preventing the blowing of the coal dust to the cars in the rear. This is a sheet iron covering arranged with two large hinged doors which can be swung back for filling the tender.

The point of greatest interest in this locomotive is found in the design of the cylinders and valve, detail drawings of which are shown herewith. The operation of two simple cylinders connected at 180 degs. with each other by a single piston valve introduces some new problems into the cylinder design, which it can be seen have been solved in a very straightforward manner. The valve chamber has but two steam ports, each of which is connected to opposite ends of the two cylinders on that side by passages which are of ample area and are comparatively unrestricted. This permits the use of the same type of piston valve and bushing as would be used with a simple engine, since an opening in the port allows the steam to enter the rear of one cylinder and the forward end of the other at the same time and in equal amounts, thus giving each piston equal pressure and maintaining the balance. The combined area of these two 12½ in. cylinders is about equal to the area of a single 17¾ in. cylinder, from which it can be seen that the port opening necessary to supply the proper volume of steam through a 10 in. piston valve would not be any greater than would be necessary on a simple engine, thus allowing the design of the valve gear as well as its setting to be undertaken in the same manner as if the engine had simply the outside cylinders in operation.

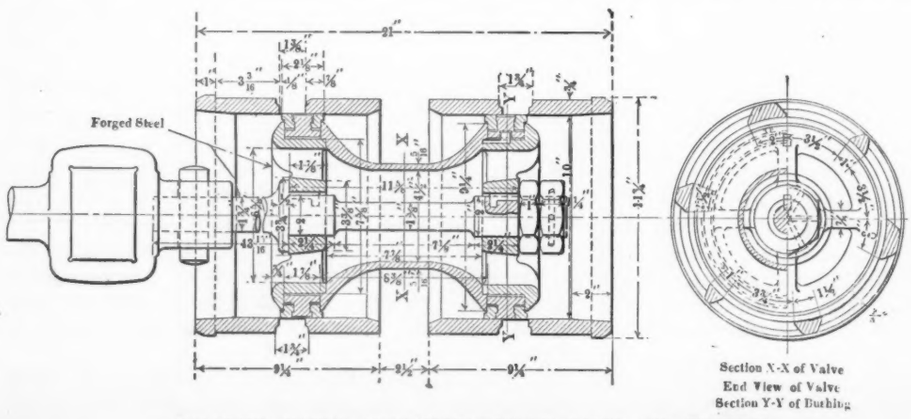
The valve gear, as mentioned above, is of the Walschaert type and operates the valve stem through a cross head connection, the cross head, however, being on the rocker arm and working in a yoke on the valve stem.

In other respects this locomotive is of the usual design for a small narrow fire box American type engine. Its weights and general dimensions are given in the table below.



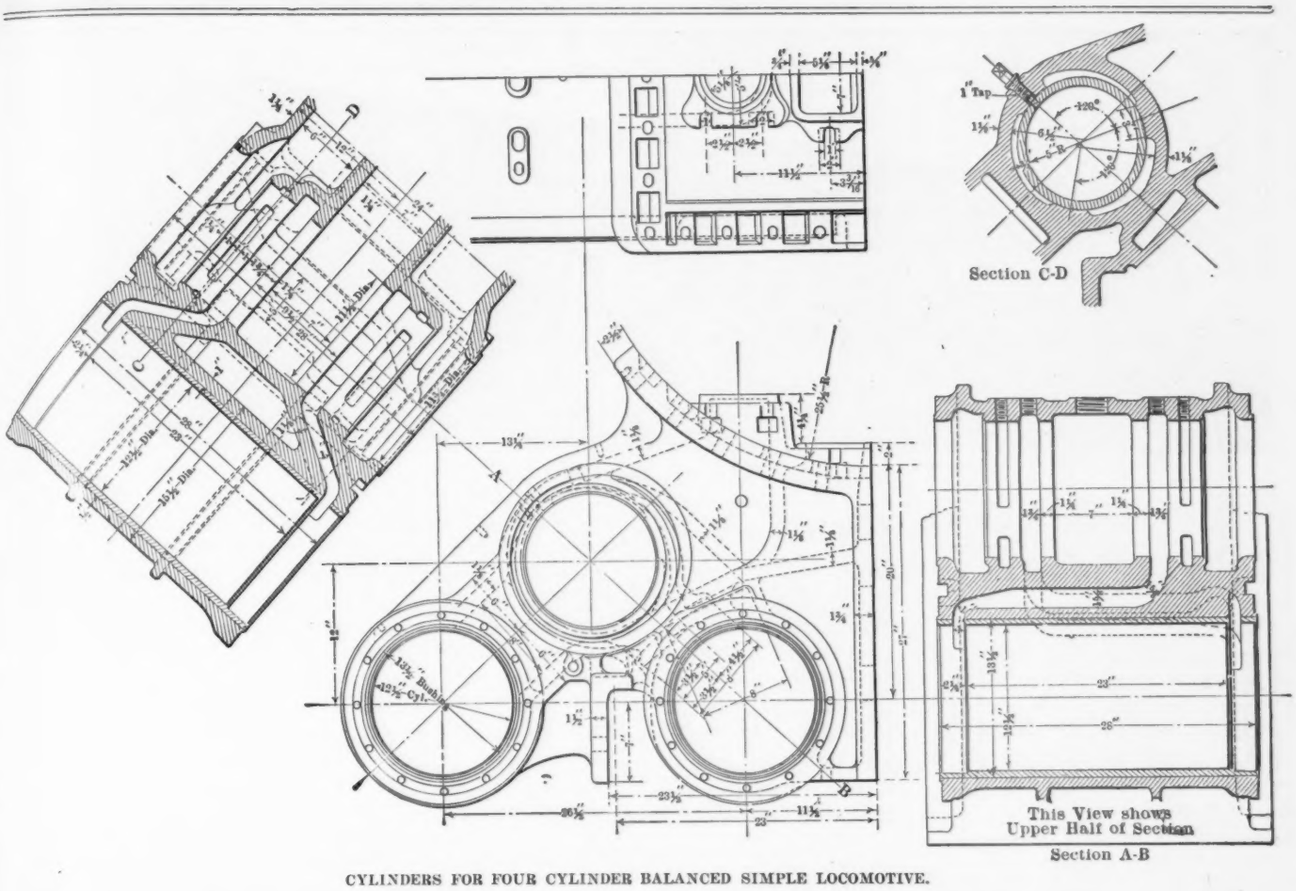
ELEVATION AND SECTIONS OF FOUR CYLINDER BALANCED SIMPLE LOCOMOTIVE—L. S. & M. S. RY.

On page 217 of our June issue we illustrated a four-cylinder balanced simple passenger locomotive built for the Belgium State Railways, which was an example of the methods used abroad for accomplishing the combination of the highly desirable balanced feature with a simple engine. That engine, however, was designed for regular high speed passenger service and can be compared with this American example only in a general way, since the service of the two engines is entirely different. However, a comparison of the two designs affords a number of points of interest and does not by any means result to the disadvantage of the American engine. The most noticeable feature of difference is found in the use of but one valve on the Lake Shore engine where two are used on the Belgium engine. This results in a very decided simplification of the machinery in connection with the cylinders, all of which is subject to wear and is a source of expense, and while the use of a single valve may be considered to complicate the cylinder casting somewhat, we believe that it is an improvement and that future American designs of this type of engine will use the single valve until the cylinders reach such a size as to make a single valve chamber unwieldy.



BALANCED SIMPLE LOCOMOTIVE—PISTON VALVE AND BUSHING.

In the matter of superheated steam as used on the Belgium engine it is by all means desirable where the locomotive is to be operated in heavy service. Its special properties of being a poor heat conductor and of rapid movement are specially desirable with this type of locomotive and will aid largely in keeping down the size of the single valve chamber for the two cylinders, as well as largely prevent the condensation losses necessarily accom-



CYLINDERS FOR FOUR CYLINDER BALANCED SIMPLE LOCOMOTIVE.

panying the increased area of passages and cylinder walls.

The general dimensions are as follows:

FOUR CYLINDER BALANCED SIMPLE INSPECTION LOCOMOTIVE.
LAKE SHORE & MICHIGAN SOUTHERN RY.

GENERAL DATA.

Gauge	4 ft. 8½ ins.
Service	Inspection
Fuel	Bituminous coal
Tractive power	15,700 lbs.
Weight in working order	126,600
Weight on drivers	85,100
Weight on truck	41,500
Wheel base, driving	9 ft.
Wheel base, total	25 ft. 1 in.
Wheel base, engine and tender	48 ft. 4¾ ins.

RATIOS.

Weight on drivers ÷ tractive effort	5.4
Total weight ÷ tractive effort	8.1
Tractive effort x diam. drivers ÷ heating surface	670
total heating surface ÷ grate area	69.5
Firebox heating surface ÷ total heating surface	9.5 %
Weight on drivers ÷ total heating surface	58
Total weight ÷ total heating surface	86.5
Volume four cylinders	5.7 cu. ft.
Total heating surface ÷ vol. cylinders	258
Grate area ÷ vol. cylinders	3.7

CYLINDERS.

Number	4
Kind	Simple
Diameter and stroke	12½ x 20 ins.

VALVES.

Kind	Piston
Diameter	10 ins.
Greatest travel	4¾ ins.
Outside lap	⅞ in.
Inside clearance	⅛ in.
Lead in full gear	⅛ in.

WHEELS.

Driving, diameter over tires	63 ins.
Driving, thickness of tires	3½ ins.
Driving journals, diameter and length	8¼ x 10 ins.
Engine truck wheels, diameter	30 ins.
Engine truck, journals	6 x 12 ins.

BOILER.

Style	Wagon top
Working pressure	180 lbs.
Outside diameter of first ring	50 ins.
Firebox, length and width	96 x 31 ins.
Firebox plates, thickness	⅜ ins.
Firebox, water space	F. 4½, B. 4, S3 ins.
Tubes, number and outside diameter	187 ft 2 ins.
Tubes, length	13 ft. 6½ ins.
Heating surface, tubes	1,326 sq. ft.
Heating surface, firebox	140 sq. ft.
Heating surface, total	1,466 sq. ft.
Grate area	21 sq. ft.
Smokestack, diameter	16 ins.
Smokestack, height above rail	14 ft. 10½ ins.
Centre of boiler above rail	6 ft. 6 ins.

TENDER.

Frame	10 in. channel
Wheels, diameter	33 ins.
Journals, diameter and length	5 x 9 ins.
Water capacity	4,300 gals.
Coal capacity	10 tons

EFFICIENCY AND ECONOMY OF THE LOCOMOTIVE.—As yet, comparatively little has been done in the improvement of the locomotive in this country in the direction of superior economy and efficiency. In Europe the high price of coal has led to care in design and in operation of locomotives which is unknown here. The French are a generation in advance of us in locomotive operation. In France, locomotive engineers use devices such as double valve gears and variable exhaust nozzles, which we do not intrust to our engineers and firemen. In England, the small number of locomotive failures on the road is a revelation to any one who studies them from our standpoint. In England the locomotive is given a fair chance by receiving fair treatment, yet it probably does not cost more in the end. We certainly have much to learn from across the water, and while what we may learn is not so much in practice as in method, it is none the less important. That which we most need to learn from England is the value of appreciation of the locomotive and locomotive men.—*Mr. G. M. Basford, at Purdue University.*

Mr. T. Roope has resigned as superintendent of motive power of the Chicago, Rock Island Island & Pacific Ry. at Topeka, Kan., to accept the position of superintendent of motive power of the Chicago, Burlington & Quincy Ry. lines west of the Missouri River, with headquarters at Lincoln, Neb., succeeding Mr. R. D. Smith, resigned.

Mr. D. R. MacBain, heretofore division master mechanic of the Michigan Central R. R., at Jackson, Mich., has been appointed assistant superintendent of motive power, with headquarters at that point.

Mr. George E. Parks, mechanical engineer of the Michigan Central R. R., with office at Detroit, Mich., has been appointed division master mechanic of the same road, at Jackson, Mich.

STEAM MOTOR CAR—CANADIAN PACIFIC RY.

STEAM MOTOR CAR.

CANADIAN PACIFIC RAILWAY.

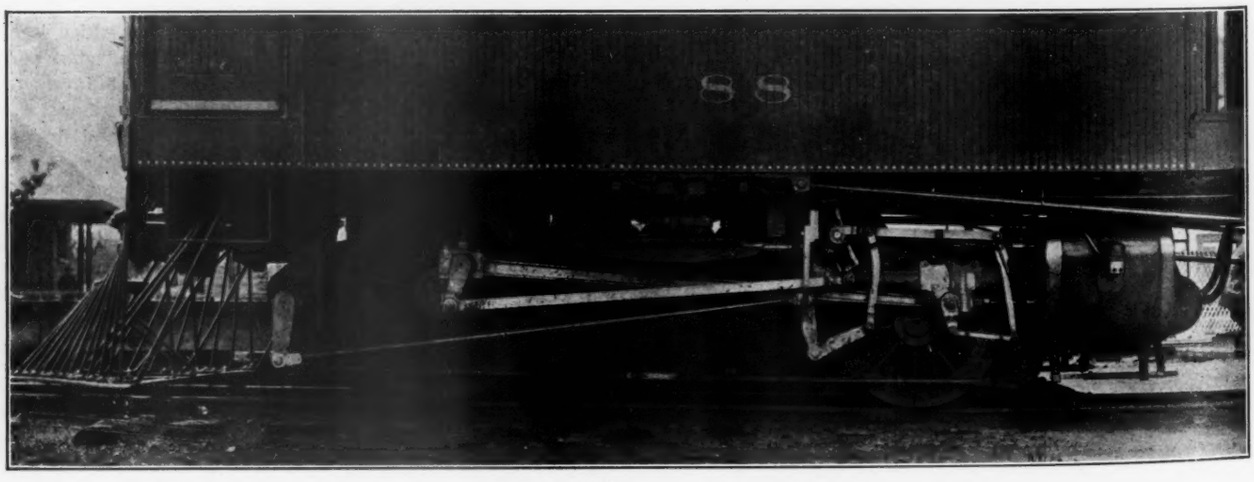
Experience with independently operated motor cars on steam railroads in this country has been confined largely to those operated by either gasoline engine direct or through the medium of an electric current from a dynamo driven by a gasoline engine located on the car, and several cars of both of these types have been illustated in this journal. The experience with motor cars on steam railroads in England and on the Continent has been, on the other hand, more extensive with cars driven by steam, and a number of successful designs have been in quite extensive service for a sufficient length of time to show that they can handle the traffic on certain branch and interurban lines with satisfaction and economy.

This successful foreign experience with steam-driven cars supplemented by several other reasons, such as the greater familiarity of trainmen with steam operation, the more satisfactory and convenient control as compared with direct-driven gasoline cars, the present greater reliability, and in some cases the cheaper operation, has led several American railroads to recently begin experimenting with this type, using in some cases cars purchased from special manufacturers, and in others cars designed and built at their own shops.

In this latter class is a steam motor car which has been in operation for some time on the Canadian Pacific Railway out of Montreal. This car was designed in the mechanical department of the road under the direction of Mr. H. H. Vaughan, assistant to the vice-president, and Mr. A. W. Horsey, mechanical engineer, and consists, when reduced to its elements, of a four-wheeled, single driver locomotive, which forms one truck of and is incorporated in the car body of a combination passenger coach. As can be seen in the illustration, an extra long body with a blind end ahead is used, which is divided into three compartments, the forward one containing the boiler and the engine control apparatus, the second being a small baggage compartment and the remainder a passenger compartment, with a platform and entrance at the rear.

The locomotive or steam motor part of the car is supported on a 4-wheel truck, the forward pair of wheels forming the drivers, and the others being trailing wheels. The truck frame is made up of ⅞-in. steel plates in a very strong and substantial manner, and the cylinders are located in the rear, being supported on an extension from the frame. The cylinders are 10 by 15 ins., and have inside admission piston valves, which are operated through a simple design of Walschaert valve gear. The illustration shows the construction and arrangement at this point very clearly. The driving wheels, which have cast steel centers, are 42 ins. in diameter, and the trailing wheels are 34 ins. in diameter. All journals are 8 by 12 on this truck.

The boiler, which furnishes superheated steam at 180 lbs. pressure and at a temperature of from 700 degs. to 760 degs. F. at the cylinders, is 54 ins. inside diameter, being of the return tube interior firebox type. The furnace consists of a 32-in. brick-lined Morrison corrugated tube, and above it are 95 1¾-in. tubes, 7 ft. 11 ins. long. The total heating surface is 536 sq. ft., of which 485 sq. ft. is in the tubes and 51 sq. ft. in the furnace. The superheater consists of 11 1¼-in. steel tubes, and contains 62 sq. ft. of heating surface. Crude oil is used for fuel, and is carried in a tank having a capacity of 2,000 lbs., which is built in the frame of the motor. A constant air pressure of 15 lbs. per sq. in. is maintained on top of the fuel oil, for forcing it up to the burner. The oil is fed



MOTOR TRUCK OF STEAM MOTOR CAR.

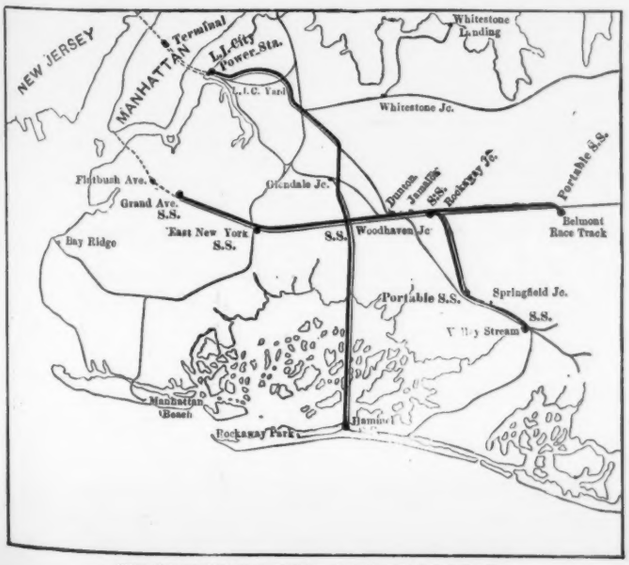
to the furnace by a slot burner of the Booth type, and the supply cock and the blower are controlled by an automatic device. The boiler feed water is carried in water tanks having a total capacity of 900 gals., which are fastened to the underside of the car body.

The total weight of the car in running order is 136,620 lbs., of which 82,880 lbs. is at the motor end of the car. Of this weight 42,440 lbs. rests upon the driving wheels. This weight bears a ratio of about 7.7 to 1 with the theoretical tractive effort, which is nearly 5,500 lbs. This car is equipped with the Westinghouse Air Brake Company's A. M. T. automatic system, which has a graduated release, and is specially adapted for this class of service.

In discussing the report of the committee on "Electricity for Steam Railroads" at the last Master Mechanics' Convention, Mr. Vaughan spoke about this car, and mentioned the fact that, in general, the data which had been found to be satisfactory for use in ordinary locomotive design would apply in the case of a car of this kind. He also stated that this car was easily capable of attaining a speed of from 50 to 55 miles per hour, and that its operation had been very satisfactory up to that time. It is operated at a cost of from 15 to 20 cents per mile.

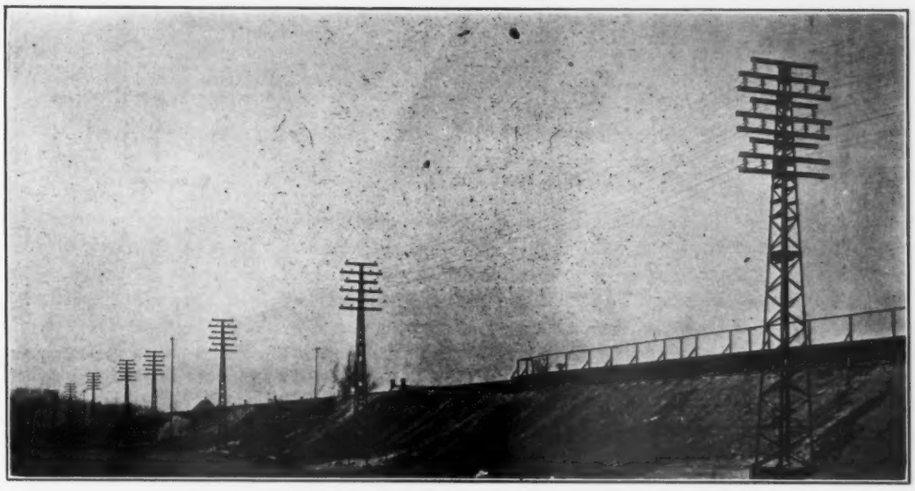
The details of this car will appear in a later number.

NEW SECRETARY OF THE A. S. M. E.—Mr. Calvin W. Rice, who has been appointed secretary of the American Society of Mechanical Engineers, and will succeed Professor Hutton at the December meeting, is a graduate in engineering from the Massachusetts Institute of Technology, and has had experience in machine shop practice, having worked up from the bench through the positions of foreman, draftsman, office engineering and district engineer of the central States. He was for several years installing and operating complete steam, hydraulic and electric plants in Colorado and Montana, and for several years was electrical engineer of the subways of the city of New York, and of the operating departments of the New York Edison Company. For the last three years he has been consulting engineer for the New York office of the General Electric Company, making a specialty of the steam turbine, and engaged in the engineering work connected with all manner of prospective propositions. Mr. Rice is a member of the American Institute of Electrical Engineers, American Society of Mechanical Engineers, the Institution of Electrical Engineers of Great Britain (having been proposed by Lord Kelvin), and a member of the American Association for the Advancement of Science.



TRANSMISSION LINES—LONG ISLAND R. R.

WALSCHAERT VALVE GEAR.—The present tendency toward the use of Walschaert valve gear is due chiefly to the desire to improve structurally rather than to improve the use of steam. It is considered advisable to remove the valve gear from a confined space under the locomotive and also, if possible, to lighten the parts and arrange them in direct lines. The Walschaert valve gear does this, and more. It substitutes easily maintained joints and pin connections for the very large and inaccessible eccentrics, and it provides an arrangement which is not as liable to derangement as is the Stephenson motion.—*Mr. G. M. Basford, at Purdue University.*



STEEL POLES AND TRANSMISSION LINES—LONG ISLAND R. R.

ELECTRIFICATION OF THE LONG ISLAND RAILROAD

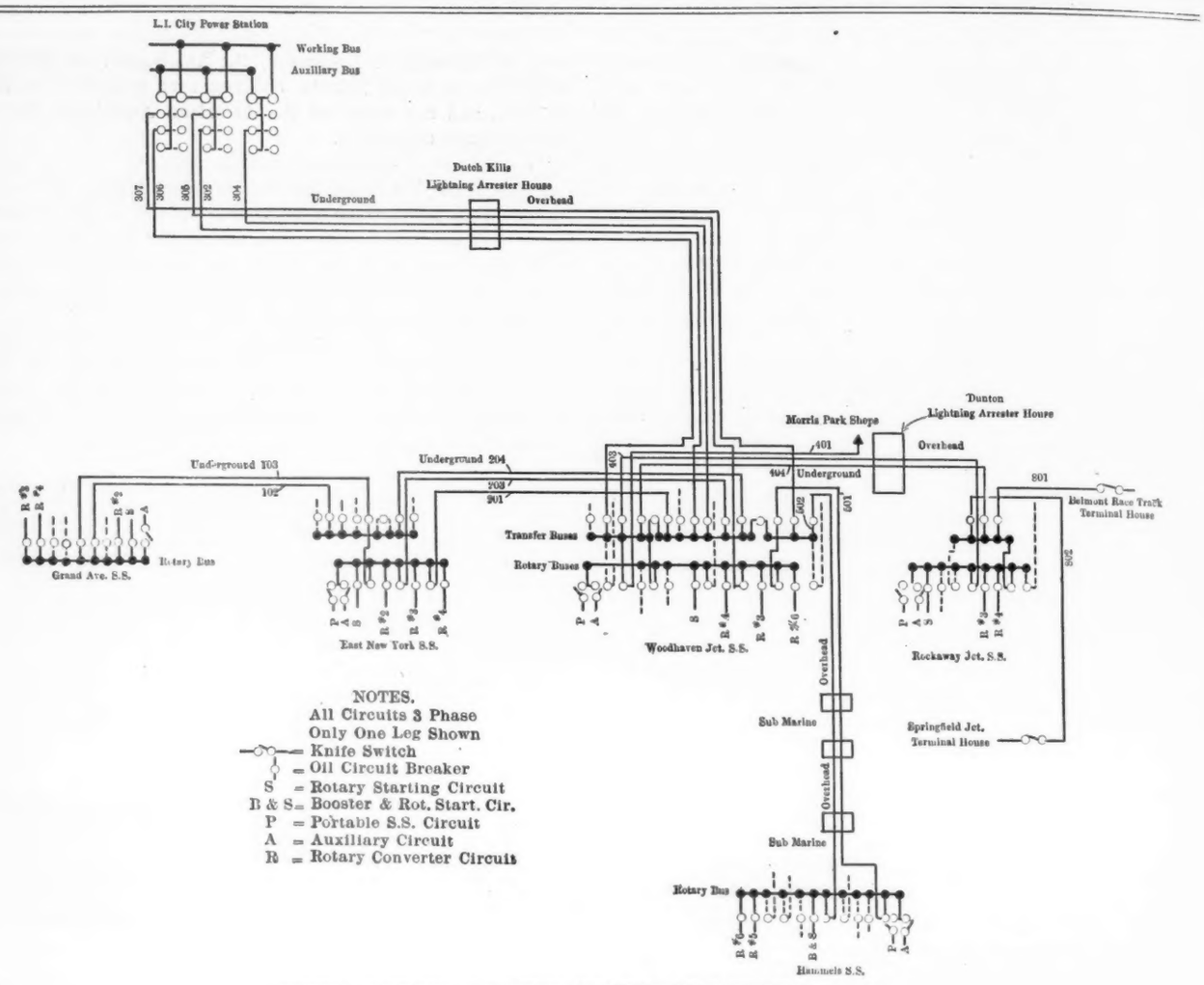
TRANSMISSION LINES AND SUB-STATIONS.

In the issue of May, page 171, we gave a very complete illustrated description of the Long Island City power house of the Pennsylvania, New York, & Long Island Railroad, mentioning the fact that it was to furnish power for the operation of trains in the tunnels underneath the East River and the Island of Manhattan, being built by the Pennsylvania Railroad, and also for trains on certain portions of the Long Island Railroad.

Coincident with the construction of the power station certain sections of the Long Island Railroad were prepared for operation by electricity and shortly after its completion some of these were put into operation and others added as soon as the track and line work could be finished. At the present time Long Island Railroad trains are being operated electrically from Flatbush Avenue, Brooklyn, to Belmont Park; from Flatbush Avenue to Rockaway Park, and from Flatbush Avenue to Jamaica via Hammel and Valley Stream. Other sections of the line will be electrified as the traffic or other conditions make it desirable and it is expected that eventually the whole suburban section of the Long Island Railroad will be operated by electricity exclusively.

In the present article we will briefly consider the methods used in transferring the current from the Long Island City power house to the trains.

The current leaves the power house as three phase alternating at a pressure of 12,000 volts. The present line consists of five circuits of three conductors each leaving the power house, which are carried underground through an 18 duct conduit line to Dutchkills Street, a distance of 1.12 miles, at which point they come to the surface and connect to light-



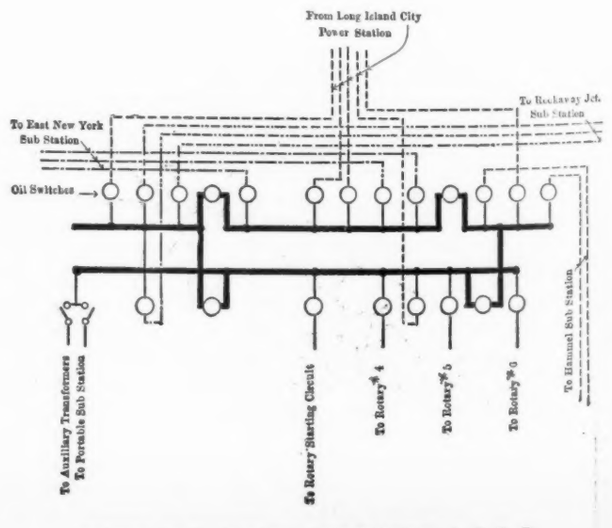
GENERAL DIAGRAM OF ELECTRIC CIRCUITS—LONG ISLAND R. R.

ing arrestors placed in a small building of fire proof construction. From this they are carried overhead on steel poles to Woodhaven Junction, a distance of 7.85 miles, where is located the largest and main sub-station, from which the current is distributed to the other sub-stations.

The conductors carrying the current consist of three cables having a cross section of 250,000 c.m., each being composed of 37 copper wires; the insulation has, of course, been given very careful attention and is suited to the conditions arising from the location of the circuit. Each length of cable was tested with a pressure of 30,000 volts after it was in place.

The overhead line between Dutchkill Street and Woodhaven Junction is carried on a special design of steel pole, the general appearance of which is shown in one of the illustrations. These poles are in various sizes to meet different conditions and are all designed to carry 24 high tension cables and 8 low tension cables each, the lowest cable being at least 25 ft. above the ground. The poles are built up of four corner angles connected together by angles and plates forming a lattice type of construction. They are tapered uniformly to the top on two sides and to within 7½ ft. of the top on the other two sides, the taper being ⅜ of an in. per ft. This taper being uniform makes the size at the base of the pole vary with the height, the tops, however, being in all cases 6 by 11 ins. in section. At the bottom the corner angle irons are tied to a base composed of plates and channels through the corners of which the four anchor bolts pass. Each pole rests upon and is fastened to a concrete foundation of a size suitable to the pole and ground. Advantage is taken of the lighting rod qualities of the poles and each is grounded through a copper plate placed beneath the foundation and connected to one of the anchor bolts. The poles are designed to stand a wind pressure at right angles to a line corresponding to a wind velocity of 100 miles per hour. Poles of heavier construction than the standard are used for anchor poles and also at sharp curves in the line. The cross arms are all of yellow pine 5 by 6 ins. section and pass through the lattice work of the pole structure resting on angle iron seats at the sides and fastened by two U. bolts.

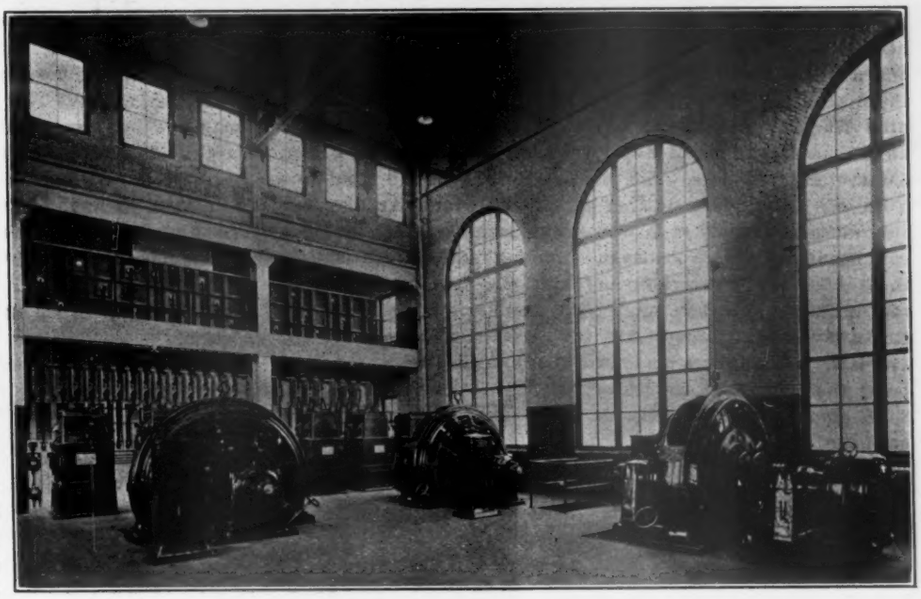
The insulator pins are of a new design and consist of a malleable iron casting clamped to the cross arm by means of a U bolt passing through the body of the pin and held by a plate fitting over the bolt ends and against the cross arm, thus avoiding reduction of strength of the cross arm by the



CIRCUIT AT WOODHAVEN SUB-STATION—L. I. R. R.

boring of a hole in it as is usually done, and also allowing the shrinkage of the arm to be followed up and the pin held tightly. The insulators are of porcelain, made in two parts, cemented together, and have the cables fastened to them by ties of soft copper wire. The poles are spaced on an average of 150 ft. apart on straight line work.

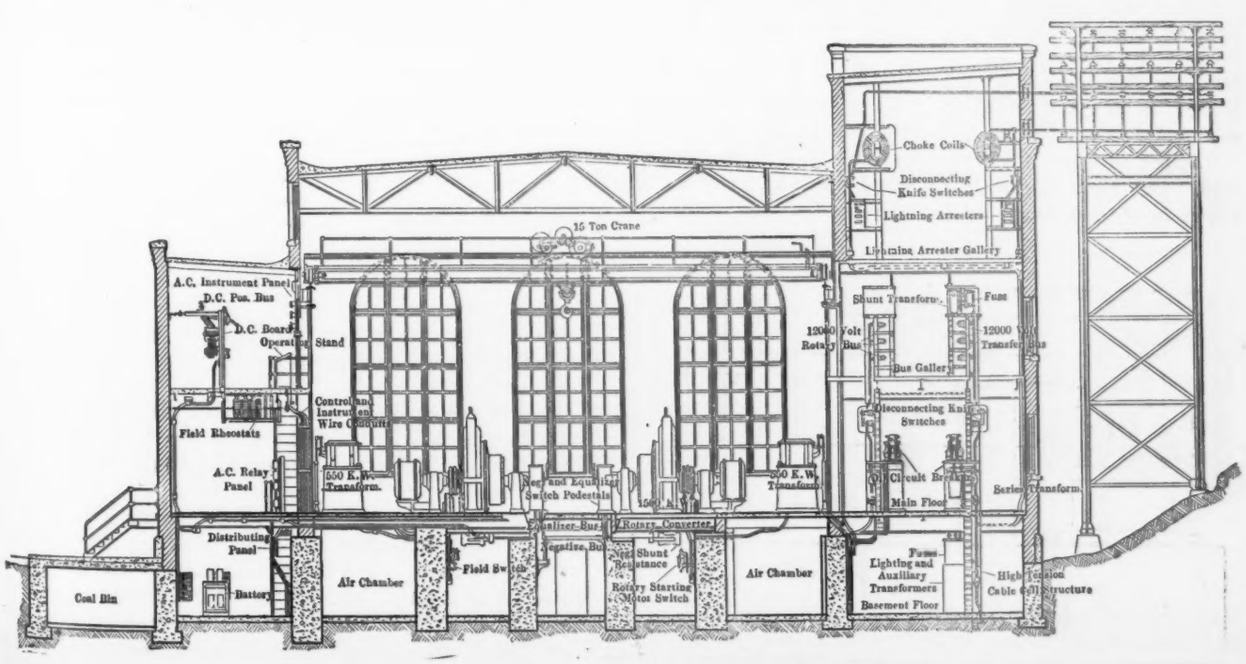
At Woodhaven Junction special terminal racks are provided alongside the station, consisting of a steel truss bridge construction about 11 ft. wide and as long as the building, to which the transmission line is fastened. This rack, which is supported at the proper height by latticed steel columns, permits the cables to be dead ended where necessary, and the connection carried across into the sub-station by a cross connector at the most convenient point. This arrangement eliminates the crossing of the cables to a large extent and in no case is there less than 2 ft. clear between high tension cables. The five circuits from the power house are brought into the Woodhaven sub-station and connected through oil switches to a set of bus bars called the transfer buses, which are divided into sections from which the outgoing transmission circuits are led in various directions. From Woodhaven there are three high tension circuits leading due west along Atlantic Avenue, being carried in an underground conduit to the East New York sub-station, a distance of 3.23 miles. At this sub-station there is a smaller set of transfer buses, and from it are carried two high tension circuits continuing underground along Atlantic Avenue to Grand Avenue, a distance of 3.04 miles, where the sub-station forming the westerly terminus of the transmission line is located. Extending easterly from Woodhaven Junction there are two high tension circuits carried underground as far as Dunton, a distance of 1.7 miles, where they pass through a lighting arrestor house to an overhead circuit and continue to the Rockaway Junction sub-station located 1.73 miles east from Dunton. From this sub-station one high tension circuit is carried to a terminal house at Belmont Park, a distance of 3.71 miles, where a connection is arranged for a portable sub-station. Also from Rockaway Junction a circuit extends south to Springfield Junction, a distance of 3.33 miles, and from Springfield Junction to Valley Stream, a distance of 2.57 miles. From Woodhaven Junction two high tension circuits are carried overhead, except at points where it is necessary to cross wide bodies of water in which case they are carried through submarine cables, to Hammel sub-station, a distance of 6.98 miles.



INTERIOR VIEW OF TYPICAL SUB-STATION—L. I. R. R.

In each sub-station are located transformers which reduce the voltage of the high tension current from 12,000 to about 375 volts. It is then passed through rotary converters which deliver it as direct current at 600 volts, in which form it is conducted directly to the third rail.

The capacity of each of the sub-stations was determined after a very careful examination of the electric schedule proposed by the railroad officials and each sub-station was constructed to accommodate the necessary machines to give the



CROSS SECTION OF WOODHAVEN SUB-STATION—LONG ISLAND R. R.

maximum current that any future probable traffic would require, although at present but part of the equipment was needed and has been installed. At Grand Avenue, which is but a very short distance from Flatbush Avenue terminal, there are at present three 1,000 k.w. rotary converters and nine 375 k.w. transformers. Although space is provided for an ultimate capacity of five 1,500 k.w. converters and fifteen 550 k.w. transformers. The present capacity of the East New York sub-station is the same as that at Grand Avenue, but the ultimate capacity is somewhat smaller. The present equipment of the Woodhaven Junction station consists of three 1,500 k.w. converters and nine 550 k.w. transformers; the ultimate capacity being just double the present. At Rockaway Junction there are two 1,000 k.w. converters, six 375 k.w. transformers and two 162 k.w. boosters. At this point there is a storage battery of 3,200 ampere hour capacity at the one-hour rate.

The sub-station equipment also includes two portable sub-stations, each of which consists of a car containing one 1,000-k.w. rotary converter and three 375-k.w. transformers, together with the necessary blower, switchboard, circuit breaker, etc.

The storage battery was installed at Hammel, because this point is the farthest from the power station of any of the sub-stations and is connected by a transmission line occupying a somewhat exposed position in passing across Jamaica Bay, and is more liable to interruption in service by accident than any other part of the line. There is also a very large fluctuation in load at this point, due to the heavy travel to Rockaway Beach on summer afternoons and evenings. All sub-stations are constructed and arranged on the same general plan, and differ only in connection with their capacity; and hence the description of the Woodhaven Junction station will apply in its different features to the other stations.

The cross section of the Woodhaven sub-station herewith will give a very clear idea of the construction of the building and the arrangement of the apparatus. It will be seen that the rotary converters and transformers are located in the large central bay, which is flanked on either side by narrower bays, one of which is for high tension distribution and control apparatus and the other for the low tension instruments and the station operating board. The foundations of the transformers are open in the center for the passage of the air blast used for cooling, there being an electrically driven blower in each station which gives a pressure of one ounce per square inch, into the interior of these foundations, where it escapes through the proper passages and cools the windings. The high tension cables enter the building at Woodhaven in the top story of the high tension bay, where they connect to the lighting arrestors and choke coils. These are located on the third floor of this gallery. They are then carried down the outside wall into the basement where they cross beneath the floor and connect to the oil circuit breakers on the main floor. This bank of oil switches, directly underneath the bus bars located on the floor just above, controls all the circuits that enter and leave the buses. The two sets of bus bars and accompanying oil switches are located in a parallel line, the transfer buses being on the outside. The high tension circuits which are to leave the sub-station come from the proper section of the transfer bus down to an oil switch and thence beneath the floor to the underground conduit or on up along the wall to an overhead connection.

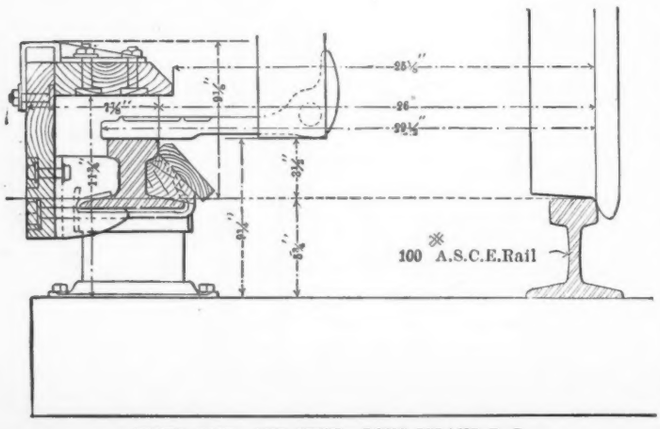
The circuits for the use of the sub-station pass down from the rotary bus bars through the oil switches, beneath the floor and thence directly to the transformers of which there are three 550 k.w. for each 1,500 k.w. rotary or three 375 k.w. for each 1,000 k.w. rotary. These transform the current from 12,000 volts to 400 volts and have taps arranged to enable the use of primary voltages down to 10,000 voltages and secondary voltages down to 340 voltages. From thence the circuit is again carried beneath the floor to the rotary converters which in the case of the 1,500 k.w. size are rated to deliver 2,400 amperes at 625 volts. These convert the current from alternating at 400 volts to direct current at 625 volts. The connections then pass beneath the floor to the low tension switchboard and after passing through the usual indicating and control instruments are conducted beneath the ground to the third rail at a point adjacent to the sub-station. The number of third rail connections vary with the number of tracks, switches, etc., in the vicinity. There are no feeder lines to the third rail between sub-stations and each sub-station connects to each adjacent sections of track, which sections are insulated with a space sufficient to prevent a single car from spanning the two sections, thus preventing burning out the car motors in case any section accidentally becomes grounded.

PORTABLE SUB-STATION AND HOUSE—L. I. R. R.

In the large sub-stations there are four sets of auxiliary transformers and in the others three sets, which supply current for driving the rotary converter starting motors, the transformer blower motors, the induction motor generating set, which is used to charge the small auxiliary storage battery that supplies current for the electric switch control system, and for the house lighting. These transformers are 50 k.v.a. capacity and receive their current from the rotary bus bars.

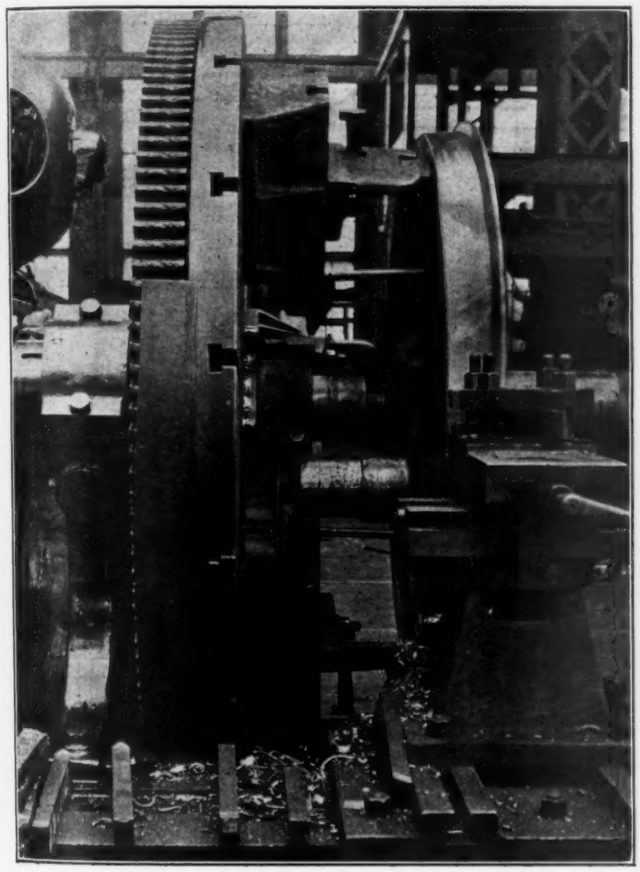
Most of the sub-stations have a track connection which permits the portable sub-stations to be run inside the building and connected up so as to temporarily increase the capacity of the station.

At Hammel, as above mentioned, there is a large storage battery which comprises 300 elements of the Electric Storage Battery Company, chloride accumulators, each element composed of 55 type R. plates. This battery has a normal one hour rating of 3,200 amperes and is so connected into the circuit that it automatically aids the rotary converter in carrying the peak of the load or absorbs the excess current.



THIRD RAIL AND SHOE—LONG ISLAND R. R.

Buildings for housing and connecting the portable sub-stations into the track circuit are provided at Belmont Park and Springfield Junction, where there is an excessive amount of traffic during the racing season, which only occurs part of the day for a few weeks each year and hence is not constant enough to demand a permanent sub-station and still is great enough to make it desirable to transmit the high tension current and transform it rather than depend upon the low tension current from the nearest sub-station. These portable sub-stations are simply a heavy steel car on which is mounted one 1,000 k.w. rotary converter with three 375 k.w. transformers and switchboard and necessary auxiliary. The houses are of reinforced concrete construction and simply large enough to contain two portable sub-stations and have a 3-ft. platform along the side. A single high tension circuit is



APPLICATION OF SURE GRIP DRIVERS TO WHEEL LATHE, L. S. & M. S. RY.

brought to this building and the regular low tension connections are made to the rail.

The third rail used throughout the system is located with its gauge line 26 ins. from the inside gauge line of the running rail and with its top 3½ ins. above the top of the track rail. It is of the top contact type and is protected with a horizontal type of guard extending directly over the rail as shown in the illustration herewith. The rail, which is of the T section 4 ins. high with a 3-in. head and 6-in. bottom flange, weighs 100 lbs. per yard and is mounted upon vitrified clay insulators, set on extra long ties at 10 ft. spaces. At each grade crossing it is necessary to discontinue the third rail and its circuit is continued by a cable in a concrete conduit underneath the road crossing and connecting to the section of the rail on the opposite side.

The return circuit is made through the regular running rails and also through the guard rails where possible. The third rail is split up into sections, connections between which are made through a knife switch placed in a small box near the rail by means of which any section can be cut out and permit safe track work. These sections are usually so arranged as to be between cross-overs, thus allowing trains to cross over and pass around the dead section.

The design and construction of both the transmission line and sub-stations was carried out by Westinghouse, Church, Kerr, & Company, engineers for the Long Island Railroad Company, and the entire work was under the direction of Mr. George Gibbs, chief engineer of electric traction, subject to the approval of an electrical committee consisting of the chief operating officials of the road with the president as chairman.

IMPROVING THE OUTPUT OF A DRIVING WHEEL LATHE.

The illustration shows an interesting application of the "Sure Grip" drivers to an 84-in. Niles driving wheel lathe at the Collinwood shops of the Lake Shore & Michigan Southern Railway. This lathe was installed a number of years ago, and while it is by no means an old machine, it is, of course, not equipped with several of the features which have been more recently added and which have greatly increased the efficiency of this make of driving-wheel lathe. It was desired to increase its capacity, but instead of boring out the face plate to permit the crank pin to pass through it and then closing up the face plates after the wheels were in position, so that the "Sure Grip" drivers could be used to advantage, the extension castings were made, of such size as to provide clearance to the largest crank pin, to which the drivers are attached. Three drivers are used on each face plate and each wheel is held securely to the drivers by two long bolts.

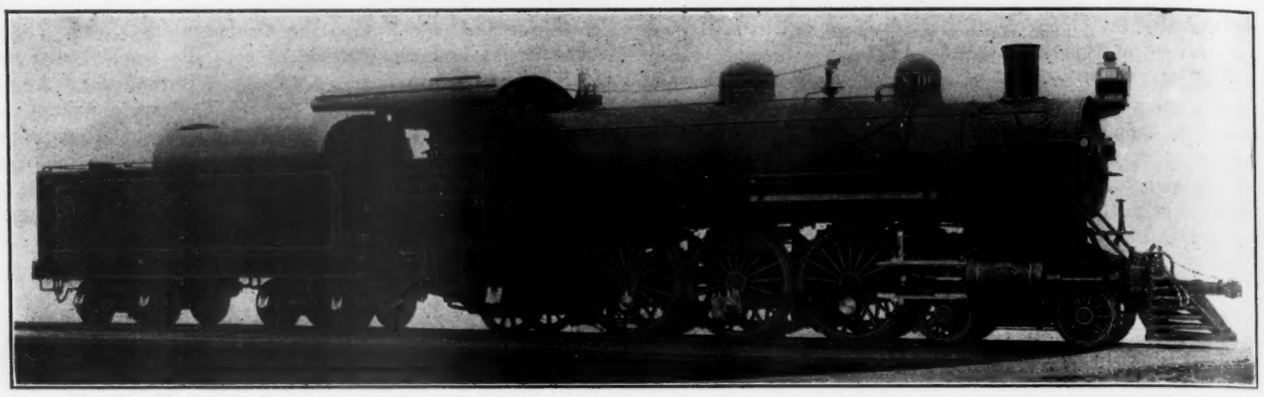
To expedite the setting of the wheels a screw attachment was applied to the head with a motor drive, enabling it to be moved quickly out of the way when changing wheels. This device has not only increased the output of the lathe, but has also reduced the strains on it. In the month of March, on a nine-hour day, one man turned 93 pairs of drivers of all sizes on this machine. We are indebted for information to Mr. M. D. Franey, superintendent of the shops.

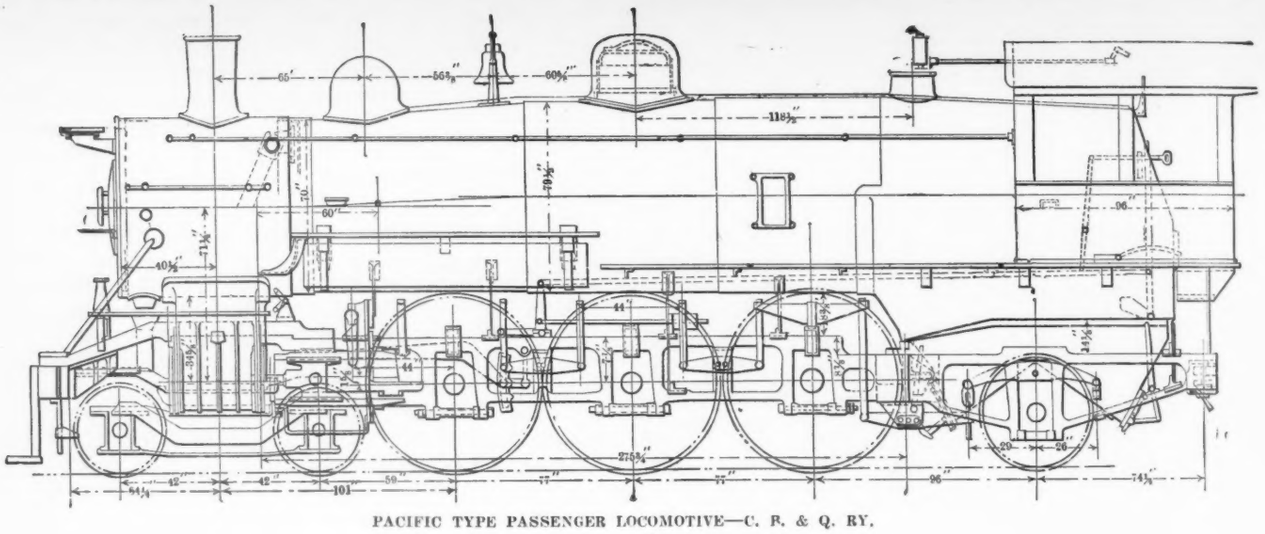
MAKE HASTE SLOWLY.—A word seems to be needed as to progress. In studying the careers of successful men, a prominent fact is developed which seems specially applicable to a successful railroad man. Those who have really advanced most rapidly and have risen highest have usually advanced slowly during the first dozen years. It is believed that an attractive feature has been pictured for those who prepare and equip themselves in the right way to carry the mechanical railroad burden of the future. It most assuredly will pay to prepare thoroughly and well, for those who do this are sure to be greeted with most brilliant opportunities. In order to prepare thoroughly and well, however, years of experience are required.—*Mr. G. M. Basford, at Purdue University.*

MECHANICAL GRADUATES.—The report of the Committee on Statistics of Engineering Education, presented at the Ithaca meeting of the Society for the Promotion of Engineering Education by Professor William T. Magruder, of Ohio State University, showed that in 1904 there were granted a total of 2,493 degrees in engineering. The most important degrees bestowed were classified as follows:

	Degrees for Post-graduate work.	Baccalaureate degrees.
Civil Engineering	28	613
Mech. Engineering	20	615
Elec. Engineering	19	413
Mining Engineering	3	228
Mech. Eng. & Elec. Eng.	..	28
Metallurgy	..	14

The general testimony was that applications for men by employers were still much in excess of the number of graduates turned out.



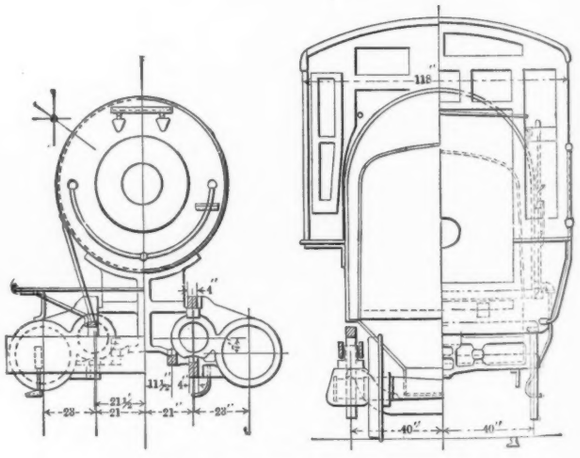


PACIFIC TYPE PASSENGER LOCOMOTIVE—C. B. & Q. RY.

PACIFIC AND PRAIRIE TYPE LOCOMOTIVES.

CHICAGO, BURLINGTON & QUINCY RAILWAY.

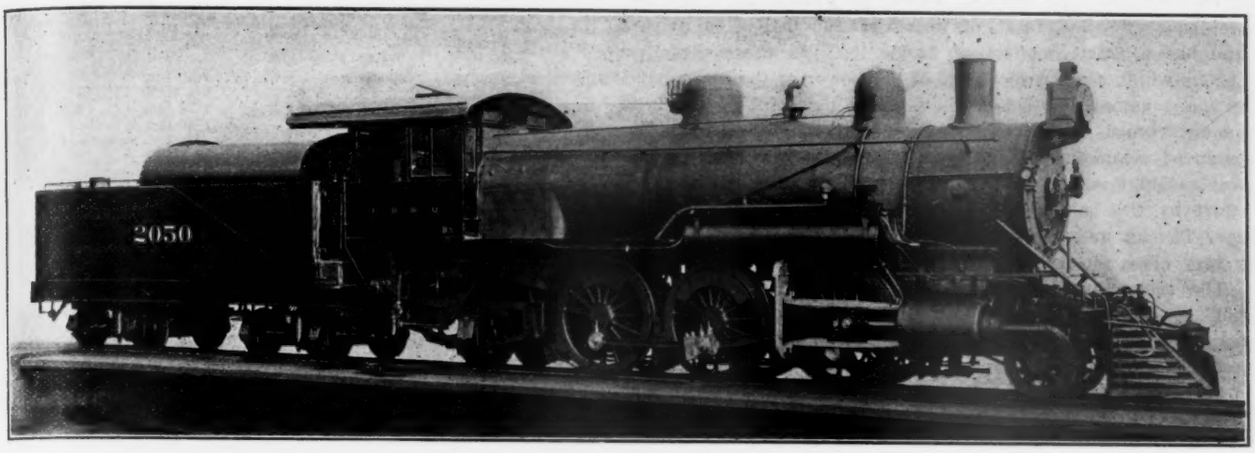
Early in the year 1900 the Chicago, Burlington & Quincy Railway built at its own shops some Prairie type locomotives, being the pioneers in the present development of the use of the wide firebox with large grate areas, for burning soft coal. (See AMERICAN ENGINEER, April, 1900, pp. 103.) These engines were built after designs prepared by Mr. F. A. Delano, superintendent of motive power and Mr. F. H. Clark, then mechanical engineer. They were known in the railroad company's classification as Class R1 and included several original ideas of design, particularly in the construction and arrangement of the trailer truck and frame under the firebox. They had 19 by 24-in. cylinders, 64-in. wheels and a steam pressure of 190 lbs., which gave a tractive effort of 21,860 lbs. The total weight was 138,000, of which 94,000 lbs. was on drivers.

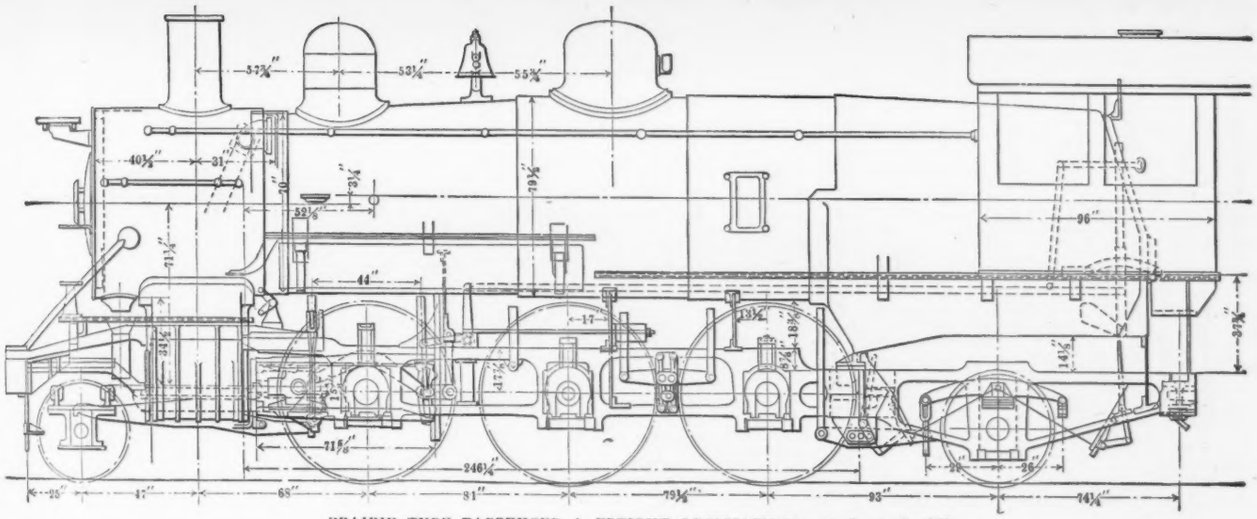


SECTIONS OF PACIFIC TYPE LOCOMOTIVE.

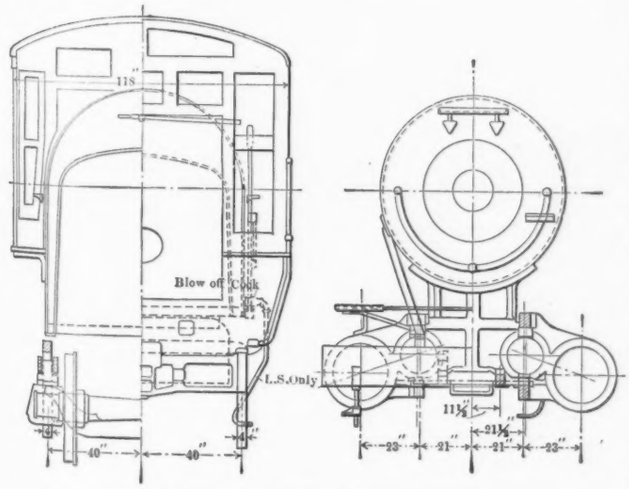
	R1.	R2.	R3.	R4.	R5.	S1.
Total Weight	138,000	171,000	181,920	212,500	216,000	230,940
Weight on Drivers	94,000	130,000	134,550	154,000	159,540	151,290
Tractive Effort	21,860	25,500	28,300	35,060	35,060	32,690
Steam Pressure	190 lbs.	200 lbs.	200 lbs.	210 lbs.	210 lbs.	210 lbs.
Size, Cylinders	19 x 24	20 x 24	21 x 26	22 x 28	22 x 28	22 x 28
Wheel, Diameter	64	64	69	69	69	74
Total Heating Surface	1,958	2,888.5	3,060.5	3,514	3,576	3,933
Grate Area	42	42	42	54	54	54
Tractive Effort × Dia. Drivers ÷ Heating Surface	717	565	640	687	677	615
Weight on Drivers ÷ Heating Surface	48	45	44	43.6	44.6	38.5
Vol. Cyls., cu. ft.	7.88	8.74	10.4	12.32	12.32	12.32
Total Heating Surface ÷ Vol. Cyls.	248	330	294	285	290	318

TABLE GIVING GENERAL DIMENSIONS OF PRAIRIE AND PACIFIC TYPE LOCOMOTIVES—C. B. & Q. RY.





PRAIRIE TYPE PASSENGER & FREIGHT LOCOMOTIVES—C. B. & Q. RY.



SECTIONS OF PRAIRIE TYPE LOCOMOTIVES.

These were followed shortly after by the Class R2, which was in general an enlargement of the preceding class and had 20 by 24-in. cylinders, 64-in. wheels and 200 lbs. of steam pressure. This second class was followed later by Classes R3 and R4, which had 21 by 26 and 22 by 28-in. cylinders respectively, both having 69-in. drivers. The latter of these had its steam pressure increased to 210 lbs., and also differed from the preceding three classes in the use of the radial stay boiler in the place of the Belpaire. There was also a change made in the location of the valve chamber on the Class R4, it being placed between the double bar front frame instead of over the cylinder as in the previous classes.

These four classes were described and illustrated in the American Engineer and Railroad Journal in the following numbers: April and July, 1900, pages 103 and 217; May, 1901, page 135; November, 1902, page 343 and March, 1905, page 78.

The latest step in the development of this particular type of locomotive on the C. B. & Q. Ry. is shown in an order recently received from the Baldwin Locomotive Works, which are titled Class R5 and are illustrated herewith. These engines differ but slightly from the Class R4, which fact can be taken as an evidence that for the service required, which is largely fast freight and moderate speed heavy passenger, they have proved to be entirely satisfactory as far as power and general design are concerned.

The most noticeable change made is the return to the wagon-top boiler, which was used on the first three classes in place of the straight boiler used on the Class R4. However, the diameter at the front ring is the same on the Class R4, and the barrel from the second ring backward has been enlarged to 79½ ins., giving a considerable increase in steam storage space. This addition to boiler capacity has resulted in a slight increase in the weight on drivers and total weight, but in other respects the two engines are essentially alike.

In connection with this order of Prairie types, of which there were 50 built, there were 15 Pacific type locomotives built by the same company, which are very similar to them. The principle changes made, are in the boiler shell which has been lengthened about 2 ft., and in the wheel spacing which has been changed to allow three 74-in drivers and a four-wheel leading truck, instead of a two-wheel truck. The extension of the boiler shell was accompanied by an extension in the flue length, making the flues in the Pacific type engine 21 ft. long. This is, we believe, with the exception of the Mallet compound locomotive of the Baltimore & Ohio Railroad, the first example of flues of this length in this country.

The Pacific type engine, which is known as Class S1, weighs 230,940 lbs. total, of which 151,290 lbs. is on drivers and has a tractive effort of 32,690 lbs. In these three respects, which are a direct gage of the power of the locomotive, it ranks among the heaviest and most powerful of the type on our records, being exceeded in total weight only by the balanced compound Pacific type for the Oregon Railway and Navigation Company and in weight on drivers and tractive effort by the balanced compound Pacific type of the Atchison, Topeka and Santa Fe, to both of which engines it is a very close second.

The accompanying table gives the general dimensions of each step of this direct progression in the locomotive design from the first of the Prairie type built in 1900, and it will be seen that during the five years there has been an increase of 60 per cent. in tractive effort between the R1 and the R5 and 56½ per cent. increase in total weight. The similarity of the Classes R4 and R5, however, would indicate that the future will show but little further increase in these respects and that the greater attention is now being given to improvements of details of design and operation as a solution of the increased traffic requirements.

VALVES.		
Kind	Piston	Piston
Diameter	12 ins.	12 ins.
WHEELS.		
Driving, diameter over tires	69 ins.	74 ins.
Driving, thickness of tires	3½ ins.	4 ins.
Driving journals, all dia. and length	9½ x 12 ins.	9½ x 12 ins.
Engine truck wheels, diameter	37¼ ins.	37¼ ins.
Engine truck journals	6 x 10 ins.	6 x 12 ins.
Trailing truck wheels, diameter	42½ ins.	48 ins.
Trailing truck, journals	8 x 12 ins.	8 x 12 ins.
BOILER.		
Style	W. T.	W. T.
Working pressure	210 lbs.	210 lbs.
Outside diameter of first ring	70 ins.	70 ins.
Firebox, length and width	108⅛ x 72¼ ins.	108⅛ x 72¼ ins.
Firebox plates, thickness	⅝ & ½ in.	⅝ & ½ ins.
Firebox, water space	4½ & 4 ins.	4½ & 4 ins.
Tubes, number and outside diameter	303-2¼ ins.	303-2¼ ins.
Tubes, length	19 ft.	21 ft.
Heating surface, tubes	3,370 sq. ft.	3,732 sq. ft.
Heating surface, firebox	190 sq. ft.	190 sq. ft.
Heating surface, total	3,576 sq. ft.	3,933 sq. ft.
Grate area	54 sq. ft.	54 sq. ft.
Centre of boiler above rail	106⅝ ins.	110 ins.
TENDER.		
Tank	Water bottom	Water bottom
Frame	Steel	Steel
Wheels, diameter	33 ins.	37¼ ins.
Journals, diameter and length	5½ x 10 ins.	5½ x 10 ins.
Water capacity	8,000 gals.	8,000 gals.
Coal capacity	16 tons.	16 tons.

AUTOMOBILE AND FURNITURE CAR, LAKE SHORE AND MICHIGAN SOUTHERN RY.

The following table gives the general dimensions, weights and ratios of these two types.

FREIGHT AND PASSENGER LOCOMOTIVES.

CHICAGO, BURLINGTON & QUINCY RY.

Type	2-6-2	4-6-2
Service	Freight.	Passenger
Fuel	Bit. coal.	Bit. coal
Tractive effort	35,060 lbs.	32,690 lbs.
Weight in working order	216,000 lbs.	230,940 lbs.
Weight on drivers	159,540 lbs.	151,290 lbs.
Weight on leading truck	22,800 lbs.	38,650 lbs.
Weight on trailing truck	33,660 lbs.	41,000 lbs.
Weight of engine and tender in working order	368,000 lbs.	382,000 lbs.
Wheel base, driving	13 ft. 4½ ins.	12 ft. 10 ins.
Wheel base, total	30 ft. 8½ ins.	32 ft. 9 ins.
Wheel base, engine and tender	62 ft. 2¾ ins.	64 ft. 3¼ ins.
RATIOS.		
Weight on drivers ÷ tractive effort	4.55	4.63
Total weight ÷ tractive effort	6.16	7.07
Tractive effort x dia. drivers ÷ heat. surface	677	615
Total heating surface ÷ grate area	648	713
Firebox heat. surface ÷ total heat. surface %	5.34	4.85
Weight on drivers ÷ total heating surface	44.6	38.5
Total weight ÷ total heating surface	60.7	59
Volume both cylinders	12.32 cu. ft.	12.32 cu. ft.
Total heating surface ÷ vol. cylinders	290	318
Grate area ÷ vol. cylinders	4.46	4.46
CYLINDERS.		
Kind	Simple	Simple
Diameter and stroke	22 x 28 ins.	22 x 28 ins.

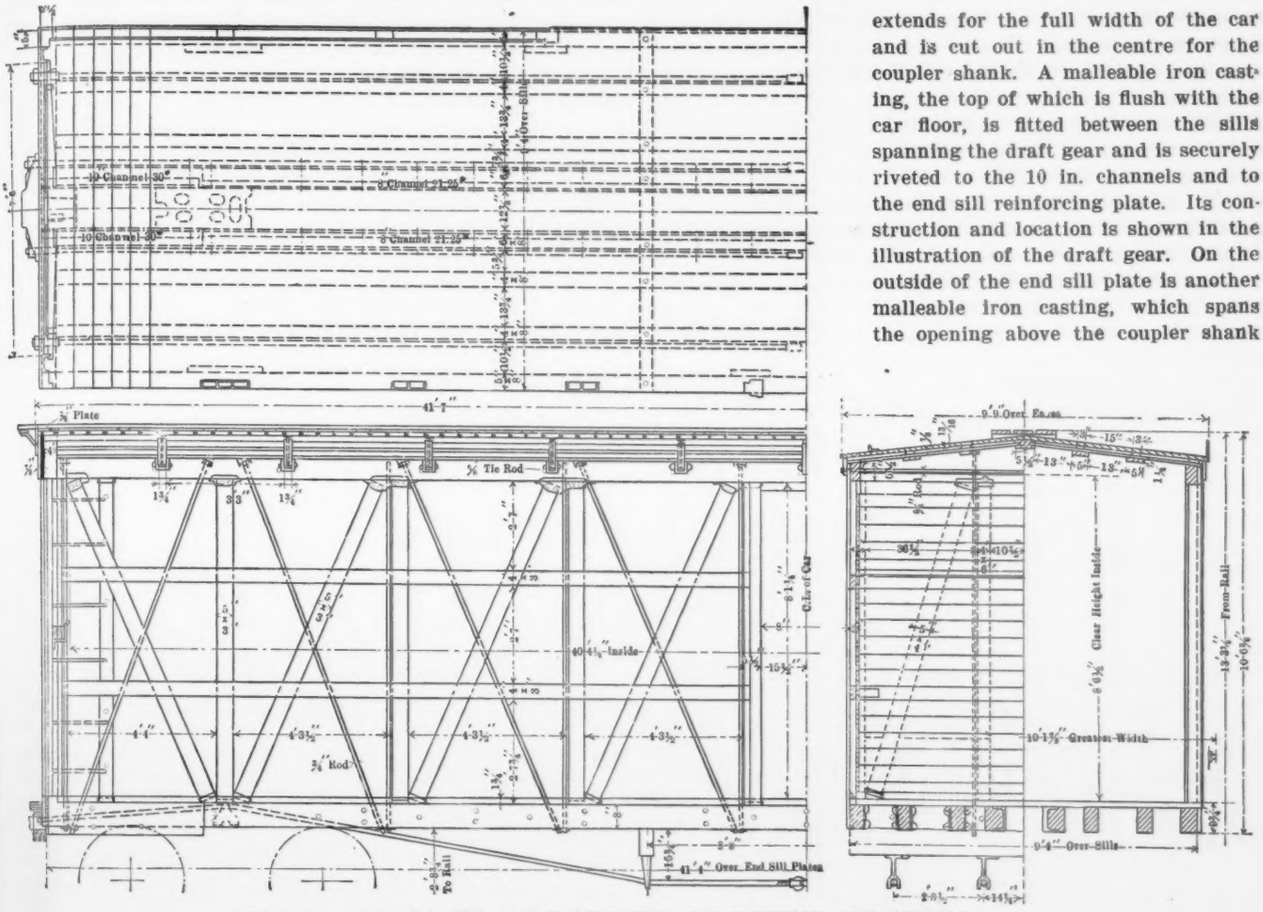
AUTOMOBILE AND FURNITURE CAR.

LAKE SHORE AND MICHIGAN SOUTHERN RAILWAY.

The Lake Shore & Michigan Southern Railway is having 1,000 box cars built at the West Detroit Works of the American Car and Foundry Company, which are specially arranged for carrying automobiles. Traffic of this nature requires a car of large inside dimensions, large door openings and of fairly large weight capacity. For fulfilling these requirements, the car, which is shown herewith, has an inside length of 40 ft. 4½ ins., and a width of 8 ft. 8 ins.; three wide door openings, one in the end of the car giving a clear opening of 7 ft. 6 ins. by 8 ft. 3 ins., and the other two located on either side, although not directly opposite each other, giving a clear opening of 8 ft. by 8 ft. 1¼ ins., and has a capacity of 80,000 lbs., its floor level being but 42⅝ ins. above the rail.

In general the construction is very similar to a modern furniture car of like size. The end door, however, occupying as it does practically the full width of the car, made special construction necessary at that point and the low floor level necessitated a draft gear application of especial interest.

The underframe comprises eight wooden sills, the two

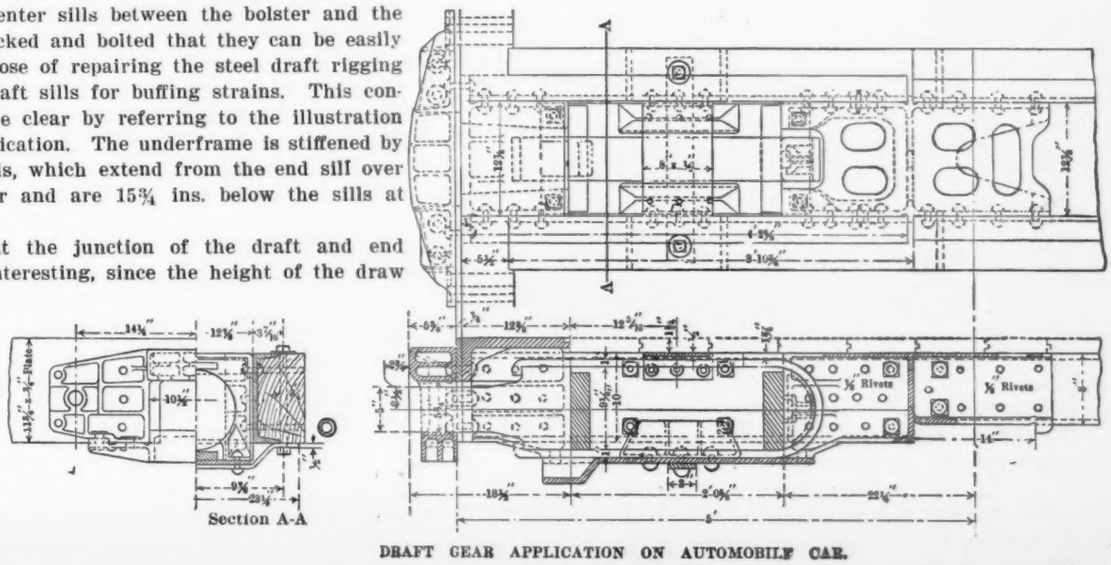


FRAMING OF AUTOMOBILE CAR, LAKE SHORE AND MICHIGAN SOUTHERN RY.

centre sills being 6 by 8 ins., the side sills 5 by 8 ins., and the intermediate sills 4 by 8 ins. All of these, with the exception of the centre sills, which terminate at the outer side of the bolster on either end, extend continuous between end sills. The center sills are reinforced by 8-in. chanels with flanges turned outward, which are fitted and bolted to the inner side of the wooden sills. From the bolster to the end sills the center sills are made up of 10 in. channels stiffened by 6 in. by 10 in. timbers. The two channel sections of the center sills are thoroughly tied together by a malleable iron casting which serves as a distance piece for the center sills and fits over the bolster, being securely riveted and bolted to both the reinforcing channels and wooden sills. This construction gives the car a set of steel draft sills. The wooden part of the center sills between the bolster and the end sills is so interlocked and bolted that they can be easily removed for the purpose of repairing the steel draft rigging and yet stiffen the draft sills for buffing strains. This construction will be made clear by referring to the illustration of the draft gear application. The underframe is stiffened by four 1¼ in. truss rods, which extend from the end sill over a chair at the bolster and are 15¾ ins. below the sills at the queen posts.

The construction at the junction of the draft and end sills is particularly interesting, since the height of the draw bar makes it necessary to discontinue the wooden end sills at the inner edge of both draft sills. The end sills are reinforced by a ⅝ in. plate on the outer face, which extends for the full width of the car and is cut out in the centre for the coupler shank. A malleable iron casting, the top of which is flush with the car floor, is fitted between the sills spanning the draft gear and is securely riveted to the 10 in. channels and to the end sill reinforcing plate. Its construction and location is shown in the illustration of the draft gear. On the outside of the end sill plate is another malleable iron casting, which spans the opening above the coupler shank and extends far enough on either side to take in the two center truss rods. This casting is securely riveted and bolted to the end sill and its plate as well as to the casting between the draft sills just mentioned, and makes up the strength and stiffness of the sill which was lost by cutting the opening for the coupler shank.

The construction of the car body, with the exception of the end containing the large doors, offers nothing unusual. The placing of a large door in the end of the car made it necessary to introduce the use of steel to get the required strength and stiffness at this point. The construction is shown in one of the illustrations. It will be seen that a

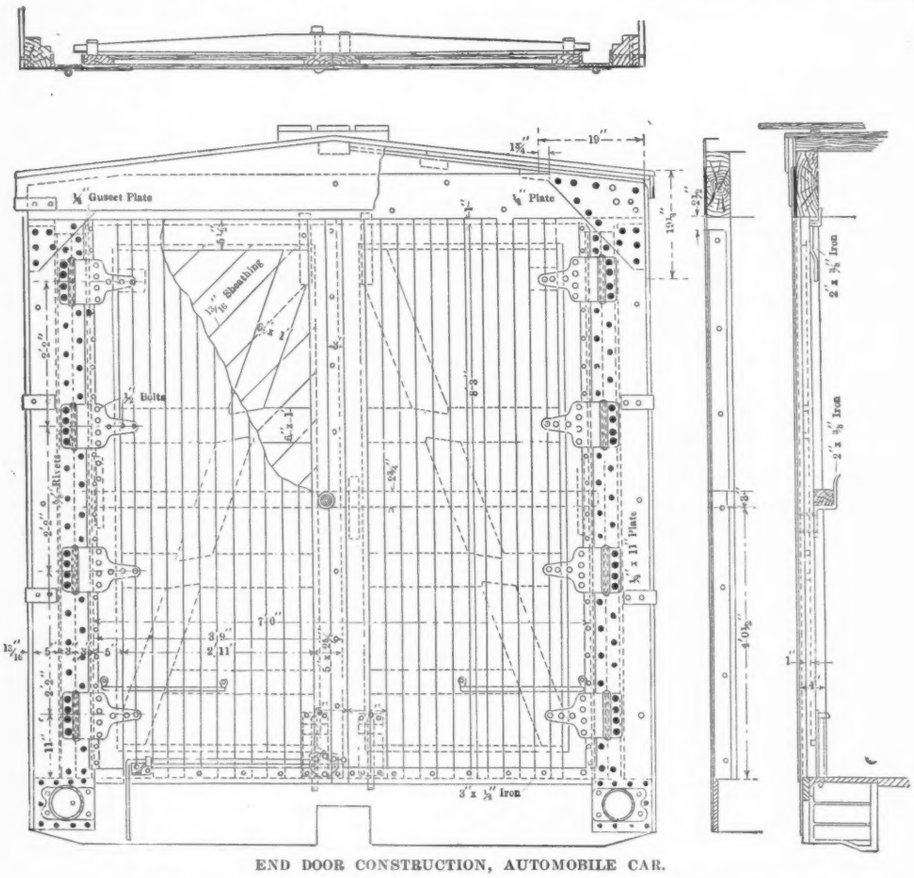


DRAFT GEAR APPLICATION ON AUTOMOBILE CAR.

¼ in. x 11 in steel plate is placed flush on the outside of the corner post. This is riveted to the end sill plate at the bottom and secured at the top by means of a gusset to a ¼ in. x 8 in. steel plate, which in turn is bolted to the wooden end plate.

The plates at the corner post are reinforced by two angle irons placed back to back, the inner one serving as a door jam and the outer one fitting against the corner post and furnishing additional means of fastening thereto. In this manner the end of the car is stiffened by a square frame work of steel plates around the door opening, securely bolted to the wooden frame work, the corner posts and end plate being the only wooden members of the car body at this point. The doors, themselves are of wood stiffly and substantially constructed and fitted with a locking bar in the center and bolted at the top and bottom. The hinges are so constructed as to give a clear opening of 7 ft. 6 in. when the doors are open.

It will be noticed that the uncoupling shaft arrangement is fastened to the door.



END DOOR CONSTRUCTION, AUTOMOBILE CAR.

The cast steel bolsters are fastened to the sills in the usual manner and are made as shallow as possible. The trucks are of the standard arch bar type.

The draft gear is of the Westinghouse friction design. Its application is clearly shown in the illustration.

We are indebted to Mr. R. B. Kendig, mechanical engineer of the road, for the drawings and information.

Mr. C. W. Van Buren has been appointed divisional car foreman of the Eastern Division of the Canadian Pacific Railway, with headquarters at Montreal.

Mr. W. E. Dunham, mechanical engineer of the Chicago & Northwestern Ry., has been appointed master mechanic on the same line at Winona, Minn.

Mr. Robert Job has resigned as chemist of the Philadelphia & Reading Ry. to become a member of the firm of Booth, Garrett, & Blair, analytical and engineering chemists, of Philadelphia.

A RATIONAL METHOD FOR THE INTRODUCTION AND MANAGEMENT OF PIECE-WORK IN A RAILROAD SHOPS.*

WILLIAM S. COZAD.†

Fourteen months ago on the Erie Railroad, with which I am connected, we commenced the work of perfecting a piece-work organization in each of the ten different shops on that road. At three of these points the shops employ an average of 1,000 men each; the seven remaining plants each average from 250 to 500 men. I am speaking now of the locomotive shops exclusively, although it might be mentioned in this connection that within the period stated above, the entire car department, the master car builder of which is a thorough piece-work man, has been reorganized and placed on a sound piece-work basis.

In the locomotive shops, however, where progress along piece-work lines is necessarily slow on account of the complex nature of the work, and also where it becomes necessary to change almost every condition before satisfactory prices can be fixed, we decided on, and have since perfected, the piece-work organization explained further on.

Piece-work, so called, was in effect in but three of the shops on the road. This made the task more difficult in these shops than at points where no prices were effective, on account of the very disorderly way in which the rates were fixed and applied. Many of the prices in effect were too high, others too low, and the descriptions of the different operations, which were written years ago, were very meager and not understood even by the foremen of the different departments whose duty it was to apply them. There were no piece-work inspectors or time checkers in the different departments of the piece-work shops. Each employee was his own piece-work and daily time checker, turning in his work and time on different operations on a blank form provided for the purpose. To correct these and many other errors, to thoroughly organize a piece-work system and place it on a sound basis in each of the different shops, to so conduct the management of the shops that the piece-work principle would appeal to all classes of the workers as being fair in its application, we outlined and have since perfected the following organization:

Mechanical superintendent, assistant mechanical superintendent, a shop specialist or piece-work expert, master mechanic of each shop, general foreman, time-keeping department, a time specialist, having the title of assistant to the general foreman, for each shop, a piece-work checker for each sub-department in shops large enough to justify it; in the small shops two or three departments are combined.

The general duties of the mechanical superintendent are well known and need no explanation here, further than to note that he finally approves each separate price before it is put into effect.

The jurisdiction of the assistant mechanical superintendent extends in a general way over all shop operations, including

*From a paper presented before the New England Railroad Club.
†Shop Specialist, Erie Railroad Company.

roundhouse expenses, shop buildings, machinery, shop ouput, etc. All appointments of general foreman, gang foremen, and piece-work checkers are made by him, subject to the approval of the mechanical superintendent, recommendations for such appointments and promotions being first made by the different master mechanics.

The shop specialist reports to and receives instructions from the mechanical superintendent, and also works in harmony with the assistant mechanical superintendent, as their interests in relation to piece-work are mutual. All piece-work schedules are made and records kept in the office of the shop specialist, as will be hereafter explained.

† Form 2351—6, 1906—5m.

ERIE RAILROAD COMPANY.

Shop_____ **Date**_____

*Description of Operation and Material*_____

*Machine*_____ *Time Started*_____ *Time Finished*_____

SPEED		FEED PER REV.		TIME-MINUTES		TIME-MINUTES		Time to Change and Grind Tools	Total Time Minutes	Pattern Number	Class of Engine
Rough Cut	Finish Cut	Rough Cut	Finish Cut	Rough Cut	Finish Cut	To Set	To Remove				

*Name of Workman*_____ *Day Rate*_____

*Remarks:*_____

_____ _____

Assistant to Gen'l Foreman.

FIG. 1.

The assistant to the general foreman is the man upon whom rests the responsibility for fixing the time upon which all piece-work prices are based. He is in many respects the most important factor in the entire piece-work organization. No piece-work expert, I care not how proficient he may become in the business, can handle all the details of rate fixing on a large railroad without relying more or less on the judgment of the man who makes the recommendations from personal observation of the work. It is to these men, therefore, who time the work personally, that we must look for fair treatment of the workmen as well as a proper conception of responsibility to the company.

These positions are made attractive both in point of salary and in placing men in line for promotion to roundhouse foreman, general foreman, master mechanics, etc., and we have aimed to select the brightest and best young men in the service for this work. Something more than mechanical ability is required in a position of this character. First of all the man must be unbiased in his opinion, and imbued with a spirit of honesty. He must be able and willing to defend the rights of the men as well as the interests of the company. It is a part of his business to study the disposition and ability of the men on the different classes of work, recommend to the general foreman changes among the workmen, which in his opinion will increase the earnings of each and also enlarge the output; study facilities, the shapes and angles of cutting tools, feeds and speeds of machines, etc. He can make himself the busiest and most useful official in the entire shop organization from an economical view, and ought to be a man of even temperament, good physique and untiring energy.

The piece-work checkers in the different departments of the shops each perform exactly the same duties, which, briefly stated, consist in carefully checking over the time and work of each employe who is paid by the piece. We depend largely, but not entirly, on these checkers to see that accurate division is made between day and piece-work time, and that the labor on the number of operations turned in by each workman is actually and accurately done. They report to the assistant to general foreman all inaccuracies of every description that may arise in the practical application of the schedules, also all operations in their respective departments having no piece-work price which are of frequent recurrence. These checkers are held responsible by the general foreman for the record of all operations appearing on card, Fig. 3, the use of which will be explained further on.

The master mechanic and general foreman of each shop have the same general control over all the details of piece-work that they exercise over the shop in general. The master mechanic is held responsible for the output of his plant and reports to the assistant mechanical superintendent in charge of shop operations on all matters pertaining to shop machinery and output, and to the shop specialist on all matters pertaining strictly to piece-work and piece-work prices.

The time-keeping department varies but little from that of the ordinary day-work shop, the only practical difference being that, instead of keeping all straight day-work time, the same clerks keep part day-work and part piece-work time. No increase in the time-keeping force is necessary in any shop on account of the introduction of piece-work.

In working out the above organization we have tried in each particular instance to recognize the responsibility resting upon each person placed in charge of a certain line of the work, and the results obtained so far have greatly exceeded our expectations. We have stimulated activity among our piece-work checkers and time specialists by a graduated scale

Schedule No._____ **ERIE RAILROAD COMPANY** † Form 2195—6, 1905—10m.

RECORD OF OPERATIONS FOR ESTABLISHING PIECE WORK PRICES.

SHOP	DATE	CARD NUMBER	PATERN NO. OR SHAPE NUMBER	CLASS ENGINE OR CAR

MACHINE	SHOP NO.	TOOL STEEL	MATERIAL	

DESCRIPTION OF OPERATION.

TIME SETTING	TIME MACHINING	TIME REMOVING	TOTAL TIME	ROUGHING CUTS			
				SPEED	FEED	DEPTH	NO.

FINISH CUT		NO. OF PIECES	OPERATIVE	RATE	COST PER PIECE	PRICE RECOMMENDED
SPEED	FEED					

Piece Work Inspector or Foreman. _____ *General Foreman.*

Remarks:_____

Approved.

Master Mechanic. *Shop Specialist.* *Asst. Mech. Supt.* *Mech. Supt.*

ISSUE_____

FIG. 2. (Size 6x9 in.)

FIG. 2.

of wages; that is, we recognize the fact that responsibility rests on some positions more than others, and we pay accordingly for the same.

We also pay a little more for positions in the large shops than we do for corresponding work in the small shops, and the young men filling these positions in the small plants understand that promotion to the large shops is sure, provided they are attentive to their work and honest in the performance of their duty both to men and management.

We are unalterably opposed to any organization that divides responsibility. If there is a dividing line between the piece-work officials and the organization responsible for the output, an absence of harmony will exist between the two forces and the production of the shop will be limited. If the

† Form 2216—3, 1905—500 Card No.

ERIE RAILROAD COMPANY.

PIECE WORK CARD.

Shop 190

Charge to	Schedule	No. Pieces	Price	Cost	DISTRIBUTION	Earnings Pro-rated	Day Rate	Total Hours	DATE AND HOURS LABOR PERFORMED	Date	HOURS	Names of Workmen	Number

Piece Work Checker. *Foreman.*

FIG. 3.

master mechanic or shop superintendent is held responsible for the output of his plant, then he should have control of the means by which that output is secured. When the officials responsible for shop production "hire" the mechanics, and the piece-work department "fires" them because in their opinion they do not quite come up to the standard, there will be more or less friction, all of which the company finally pays for in loss of production.

The card, form 2351, Fig. 1, used by the assistant to the general foreman in timing operations, calls for all the essential information necessary in rate fixing, and is 4 by 6½ ins., a convenient size for the pocket. The assistant to general foreman is instructed to note anything which would in any way affect the price, whether called for by the card or not, and this he does, either under the head of "remarks" or on the back of the card. As these cards are made out, they pass through the hands of the general foreman, and, if satisfactory to him, are turned over to the typewriter, who in turn makes out, in duplicate, card form 2195, Fig. 2. These cards are then signed by the shop officials, as indicated thereon, and sent in to the general office of the mechanical department, where they are checked and signed by the shop specialist, the assistant mechanical superintendent, and approved by the mechanical superintendent. After these cards are approved by the mechanical superintendent they are turned back to the office of the shop specialist and entered in the piece-work schedules (See Fig. 5), the schedule number placed in the upper left-hand corner (See Fig. 2), the original card filed in the file case and the duplicate returned to the master mechanic as his authority to put the price into effect. When the duplicate is received by the master mechanic it is entered in the schedule opposite the schedule number which it bears (See Fig. 2, upper left-hand corner) and filed in a case exactly like the one in the office of the shop specialist.

The piece-work record card (Fig. 3) is used by the piece-work checkers in all departments of the shop in making a record of the operation and time of all piece-workers. A record is made each day of the piece-work completed by each workman, and when the cards are full of items, or a certain amount of work is completed, they are totalled by the piece-work checker, properly signed and turned in to the general foreman's office, from which place they are sent to the time-keeping department.

The daily record cards (Fig. 4) are for the use of the workmen. They are delivered to the employees as they enter on duty in the morning, who make a record of their day's work and deposit same in box at night. Changes from day work to piece-work, or vice versa, are recorded on these cards by the gang foreman in charge of the workmen. When these cards have been checked in the general foreman's office they are turned in to the time-keeping department and checked against the piece-work cards (Fig. 3), to see what differences, if any, exist in the two records.

The piece-work schedules (Fig. 5) are all made up in the office of the shop specialist and sent out to the master mechanic to be put into effect. They are bound in Shipman's cloth binders and form a very neat book. These schedules are put in the hands of the checkers and gang foreman and otherwise distributed about the shop so that the workmen and all concerned can have free access to them.

We attribute the marked degree of success which has rewarded our efforts in the extension of the piece-work principle to the different shops of the Erie Railroad system within the past fourteen months to the perfectly free, honorable and open way in which we have placed the entire subject before our men. While other roads having shops located in towns with us have been compelled to abandon piece rates, temporarily at least, we are extending the system as rapidly as necessary improvements can be made in our shop facilities to warrant fixing a permanent price.

If, on account of changes in conditions, or for any other reason, it is necessary to alter a rate, the change is made in precisely the way in which new prices are fixed. The time specialist reports all the details of the operation, recommends the necessary change, which is signed by the general foreman, master mechanic, shop specialist, assistant mechanical superintendent, and approved by the mechanical superintendent. After the change is approved by the mechanical superintendent the duplicate card is returned to the master mechanic through the office of the shop specialist, and price in shop schedule is changed to agree with the card. Our men know just what we are doing all the time. Our time specialists have received positive instructions not to time operations for the purpose of fixing piece rates without the workman knowing for what purpose time is being taken. The old way was to get the employee on a "hurry-up" job, take the time in secret, deduct 25 or 30 per cent., and then fix the rate on the remainder—much on the same principle as an Indian would shoot his victim from ambush. Thousands of operations have in the past had piece-rate prices fixed on them by incompetent and irresponsible men, who in many cases

have posed as economical experts, and when they were put into effect one or two results always followed: either the workmen were forced to be dishonest and limit the output, or they were compelled to increase their day rate far beyond what was considered fair and equitable daily earnings by the management. If the men "soldiered" the company lost correspondingly in output; if they earned more than a fair day's pay the rates were cut, and there was dissatisfaction, perhaps a strike, among the entire force.

In the two or three shops of the Erie Railroad which have worked more or less piece-work for several years we have found it necessary within the past year to make changes in the prices on hundreds of different operations. Some were too low, many were too high, and while all may have been right when originally fixed, the marked improvement in tool steels, the introduction of modern machinery, and the change in almost every other condition about our shops has rendered it necessary to make numerous changes in old prices. We do not say to our men that we will not change prices. We do not make promises to-day which we know will be broken to-morrow. What we do say is that we will not change a rate unless we can give a good and sufficient reason for it; and when the rate is changed, it will be so fixed that an honest effort on the part of a competent workman will be rewarded by a substantial increase in earnings over his day rate.

Thirty-three per cent of the total earnings of all men employed on general locomotive repairs on the entire road is now on a piece-work basis. In the car department 56 per cent. of the freight and 92 per cent. of passenger repairing is piece-work. Over and above this we also pay piece rates on a large part of the work of our heavy repair gangs in the roundhouses. Our engine wiping is all piece-work. We knock all fires, shovel all cinders, and handle all coal at fixed prices for each separate operation. Since the workmen throughout the different departments in all our shops have become thoroughly familiar with our methods of fixing rates, we have encountered no opposition whatever in the extension of the work, and our inability to rapidly change conditions, cut out bad practices, and install proper tools and facilities for making repairs in the most economical way are now the only obstacles which prevent a more rapid extension of the piece-work principle.

* Form 2288—5,'05—50,000

ERIE RAILROAD COMPANY.

PATTERN OR SHAPE NUMBER	SCHEDULE NUMBER	NAME OF PART AND DESCRIPTION OF OPERATION	PRICE

FIG. 5.

On the machine side of our shops the operations are classified and certain machines do certain kinds of work. Our prices are, therefore, in many instances based on single machines, and if the work is changed to some other machine, we, of course, reserve the right to change the price. Each shop on the system is placed strictly on its own merits. As a whole, the schedules made for one shop are never put into effect in another shop. We do, however, where conditions and day rates are the same, frequently send prices on certain operations that have been carefully and accurately timed in one shop, to other parts of the road to be put into effect after the master mechanic and his official force are satisfied they will meet the requirements.

Men earn a great deal more money in a given time under the piece-work system than they do when working for a fixed hourly rate, and no corporation should attempt the introduction of the piece-work principle unless the management is prepared to see their employees earn increased wages. If the capacity of a blacksmith shop is to be doubled without materially increasing the force, there must be something in it for the man at the forge. On piece rates men are more interested in what they are doing, become more efficient in the application of tools, and are more contented in their positions. No "driving" is necessary. If an employee loafs, he alone, and not his employer, suffers the loss in wages.

*No.*_____

ERIE RAILROAD COMPANY.

* Form 2443 A—10, 05—250

*Daily Time Record of*_____ *Shop*_____ *Date*_____ 190

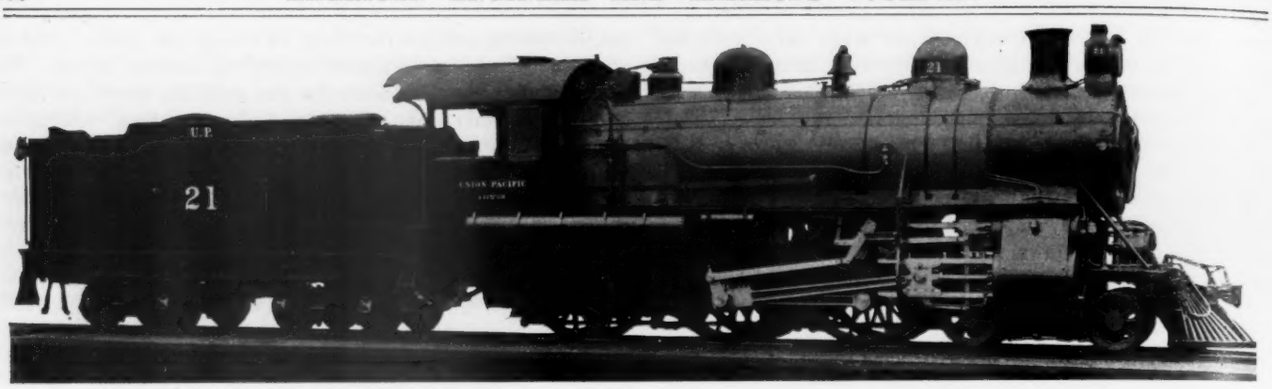
CHARGE	PIECE WORK		DAY WORK		HOURS	DESCRIPTION OF DAY WORK
	COMMENCED	FINISHED	COMMENCED	FINISHED		

FIG. 4. (Size 5 1 2x9 1-2 in.) *Correct:*_____ *Foreman.*

FIG. 4.

The piece-work system properly applied stimulates the ingenuity of the men to devise new appliances for reducing the time in handling the work. It stimulates a friendly rivalry both among the men and foreman in the different departments. It brings into immediate competition the different shops on a railroad system and benefits all alike, because each shop is turning out about the same class of work, and as opportunity is presented to show to each other the cost of details, the foreman responsible for the cost, seeing that another shop is able to produce certain work for much less than it is costing him, will at once determine the reason and apply the proper remedy. It benefits alike the employer and the workman, and any body of competent men must admit, if they are reasonable and fair, that the piece-work system, honestly administered, offers to them greater possibilities for increasing their earnings than any other method of remunerating labor, and that where their time is honestly and faithfully applied in the interest of the concern by which they are employed the reward will be proportionate to the effort.

THIRD-RAIL SERVICE DISCONTINUED.—The third-rail electric cars, which have been running on the New York, New Haven & Hartford Railroad between Hartford and Bristol, Conn., for several years, were taken off July 8 and the track restored to its former use as one of the two lines of a double track for steam trains. This action, it is stated, was taken on account of complaints of the danger of the third rail, and an injunction was issued by the court preventing its operation.



BALANCED COMPOUND ATLANTIC TYPE PASSENGER LOCOMOTIVE, U. P. R. R.

BALANCED COMPOUND ATLANTIC TYPE LOCOMOTIVE.

UNION PACIFIC RAILROAD.

The Baldwin Locomotive Works has recently delivered to the Union Pacific Railroad a balanced compound Atlantic type locomotive which embodies, as far as possible, the details adopted last year by the Harriman Lines as common standard for single expansion locomotives. These designs were illustrated and described in the AMERICAN ENGINEER AND RAILROAD JOURNAL in 1905, pages 154, 200, 250, 288, 322, 353, 400 and 441.

This engine differs from the standards principally in the design of the cylinders, valve gear, front frames, main driving axle, guide yoke and some minor parts in connection therewith. The use of the same wheel base, which was adopted for single expansion locomotives, prevented the attaching of the inside connecting rod of the balanced compound to the front drivers, and hence this rod is made with a loop spanning the front axle and connects to the second or main axle, which is cranked. The inside main rods are similar to those used on the Pacific type balanced compound locomotive built by the same company for the Oregon Railway and Navigation Company, which was illustrated in the AMERICAN ENGINEER, July, 1905, page 246.

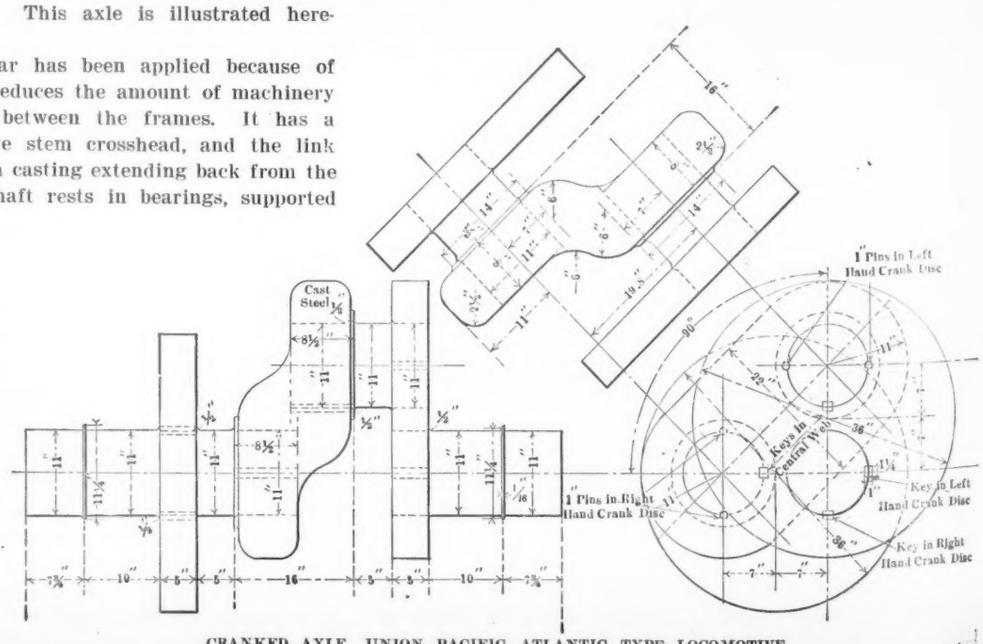
A new design of crank axle has been used on this engine, it being of the built-up type and simplified from previous built-up designs, by the employment of a steel casting in the center connecting the two crank pins in place of the two large discs and connecting piece. This reduces the total number of parts in the axle from nine to seven, and saves about 1,000 lbs. in weight. This axle is illustrated herewith.

The Walschaert valve gear has been applied because of its outside location, which reduces the amount of machinery and resulting complication between the frames. It has a separate guide for the valve stem crosshead, and the link trunnions are supported on a casting extending back from the guide yoke. The reverse shaft rests in bearings, supported from the main frames, and because of its height has an offset between bearings to clear the boiler shell. The combination lever is placed inside the guides and has its connection to the valve crosshead above the connection to the radius bar, as is necessary with inside admission valves.

In order to have all the valve gear in as near the same vertical plane as possible, the valve chamber has been changed from its usual location in balanced compound locomotives, i.e., over the frames, to a point above and 5 ins. inside the low pressure cylinder. This new location gives a very long steam port, from the valve chamber to the high pressure cylinder and a somewhat heavier cylinder, but permits the use of a simple form of valve gear. This design of cylinder made it necessary to change the standard double bar front frame used in single expansion engines to a very heavy single bar frame, which measures 6 by 4½ ins. at its connection to the main frame, and 7½ by 4 ins. where it passes below the cylinder.

The driver brake is operated by a single cylinder which is placed on the front deck plate. The push rod passes through the cylinder saddle and connects to the brake rigging at the rear. This arrangement eliminates the complication and obstruction which this part of the brake rigging would give in connection with the inside guides, rods, etc., if it was in its usual location.

The changes mentioned above have increased the weight on drivers and total weight from that given by the standard engines, and gives this engine a total weight in excess of any other Atlantic type locomotive on our records. It has a weight on drivers of 110,000 lbs., or 5,000 lbs. more than the standard engine and on front trucks of 53,000 lbs., or 8,000 lbs. more than the standard, thus giving a total weight of 13,000 lbs. more than the standard engine, or 209,000 lbs. The front truck has been lengthened 6 ins. and generally strengthened for carrying this extra weight. The cylinders are 16 and 27 by 28 ins., and the engine has a tractive effort of 26,470 lbs. The boiler and all other dimensions are the same as the standard, for which reference can be made as above mentioned.


Cast Steel
1" Pins in Right Hand Crank Disc
1" Pins in Left Hand Crank Disc
Keys in Central Web
Key in Left Hand Crank Disc
Key in Right Hand Crank Disc

CRANKED AXLE, UNION PACIFIC ATLANTIC TYPE LOCOMOTIVE.

SEMI-ELLIPTIC SPRINGS.

To the Editor:

The article on "Semi-Elliptic Springs for Locomotives and Tenders," by Mr. Musssey, on page 233 of your June number, is very interesting, and shows the hard usage a spring is put to in actual service.

But Mr. Mussey has stated one of his formulæ for the design of semi-elliptic springs wrongly. The formula for the deflection, as stated by Reauleaux and other authorities, is $D = \frac{SL^2}{Eh}$ and not $\frac{SL^2}{Eh^2}$. That is, the deflection varies inversely as the thickness of the spring plate. If Mr. Mussey has not actually stated in words during the article that the deflection varies inversely as the square of the thickness of the plate, the writing of "h²" for "h" might have been taken as a typographical error.

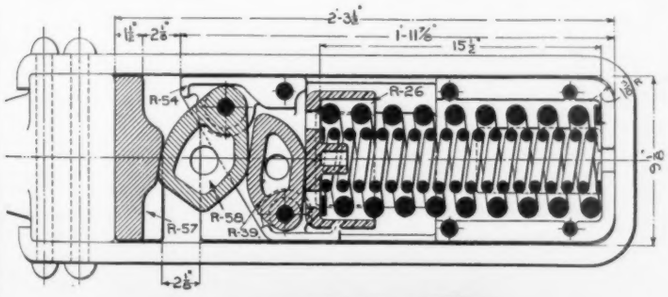
From many tests on plate springs the actual deflection has been found to very closely check the theoretical as given by $D = \frac{SL^2}{Eh}$.

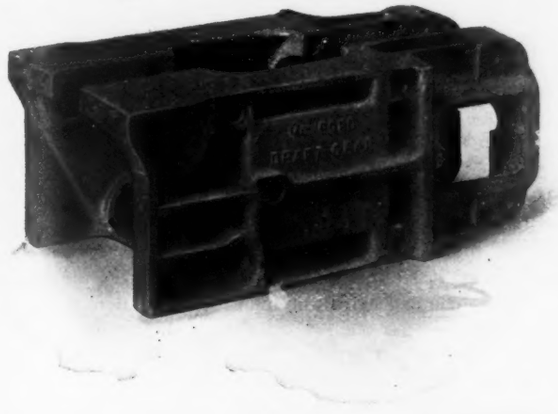
Philadelphia. H. A. F. CAMPBELL.

McCORD DRAFT GEAR.

To the Editor:

In the description of the McCord Draft Gear which appeared in your July issue a statement is made in reference to the bearings for the cam levers which is not correct. It appears in the first column on page 275, and reads as follows:





"They swing upon pins, which, as will be seen by careful examination of the whole gear, carry but little stress, and hence are of light section."

The levers do not swing upon the pins or rivets, but have their bearings and sockets in the malleable iron sides; ¾-in. rivets pass through ⅞-in. holes cored in the levers, but their only office is to hold the two malleable iron sides together.

The enclosed photographs and line drawing clearly illustrate this construction.

MORRILL DUNN,
Vice-president, McCORD & Co.

M. C. B. ASSOCIATION.

TOPICAL DISCUSSIONS.*

SHOULD NOT THE UNCOUPLING CHAINS OF PASSENGER EQUIPMENT BE SO ARRANGED AS TO GUARD AGAINST THE UNCOUPLING OF CARS IN TRANSIT BY PASSENGERS WHO MAY BE ON THE PLATFORM?—Mr. E. F. Chaffee (N. Y. C.), in opening the discussion, described three different arrangements with which he was familiar for uncoupling passenger cars, all of which employed a chain permanently fastened to an upright staff, at the top of which was a wheel or lever on the car platform. The other end of this chain was equipped with a hook for attaching to the coupler locking block. When the chain is not in use it is disconnected from the coupler and hung on an eye-bolt placed under the platform. This method requires the trainman to go between the cars in order to connect the hook to the locking block, and because of that it is considered dangerous. It was suggested that the chain be fastened permanently to the locking block and the hook be arranged to fasten to the crank on the upright staff, which would not require the trainman to go between the cars. Mr. Chaffee recommended a staff with an offset at the bottom, and a drop handle at the top with a chain fastened permanently to the locking block and a hook at the other end, as being a perfectly satisfactory arrangement.

Mr. Curtis (L. & N.) stated that he had placed on passenger cars, in place of the chain, a rod fastened to the locking block and extending out underneath the platform and ending in a handle. This is so arranged as to allow free movement of the coupler, and when it is desired to uncouple, the trainman simply pulls the rod without going between the cars at all. This can be done either from the ground or from the car steps.

DESIRABILITY OF ADJUSTING BRAKE PRESSURE TO LIGHT AND LOADED TRAINS.—Mr. West (N. Y., O. & W.) opened the discussion, and spoke at some length to the effect that it was not necessary or desirable to make arrangements for adjusting brake pressures to light and loaded trains. One reason for this was that the large percentage of air-brake cars now being run in freight trains made this feature of less importance and, judging from the experience with retaining valves, the trainmen could not be depended upon to cut out and in an apparatus for varying the brake pressures. If the air-brake apparatus as applied at present is maintained in a thoroughly efficient manner, there will be sufficient and satisfactory braking power on all trains under usual conditions. Mr. West stated that the maintaining of the condition of the present apparatus should be given more careful attention, before undertaking to apply apparatus to adjust braking pressure to light and loaded cars.

BETTER FITTING-UP OF COUPLERS, EVEN TO THE POINT OF MACHINING, OR AT LEAST DRILLING THE PIVOT PIN HOLE THROUGH COUPLER LUGS WITH KNUCKLE IN PLACE AND TAIL OF KNUCKLE FORCED AGAINST THE LOCK AND PROPER CONTOUR PRESERVED UNDER THIS CONDITION.—Mr. F. W. Brazier (N. Y. C.) opened the discussion, and spoke against the idea of drilling the pin hole with the knuckle in its coupler, since this scheme would tend to individualize the knuckles rather than make them interchangeable. He spoke concerning the strengthening of the different parts which receive the most punishment in service, and stated that with the material at present being used, there was small chance of improvement in that direction, but the better workmanship in the assembling of the parts would probably work an improvement. He believed that the expense of drilling the pin holes in the coupler lugs and knuckles, and also in the coupler shanks for the pocket rivets, would be justified. These, however, should be drilled by jigs and templets, and not by assembling each coupler for drilling.

*Continued from last month.

(Established 1832).

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Contributions.—*Articles relating to railway rolling stock construction and management and kindred topics, by those who are practically acquainted with these subjects, are specially desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase of construction.*

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The remarks of Dr. W. F. M. Goss at the last Master Mechanics' Convention on the topical discussion, "Is Not a Boiler Pressure of 185 lbs. Better Than 200 lbs. for a Locomotive?" which are given in full on page 311 of this issue, are worthy of more than passing notice. The large amount of time and expense required to keep the modern locomotive boiler carrying 200 lbs. pressure in serviceable condition is easily recognized by not only the motive power department, but also the associated departments, and that relief is desired by all is evident. Many different remedies for this trouble have been tried, some of which have resulted in considerable improvement, but there is still room for further improvement, and Dr. Goss points to a very promising opportunity to obtain it. We trust that his remarks will be given the careful attention that they deserve.

One thing that delays a new shop plant in getting the output for which it is designed is the absence of chucks, jigs, handy devices, etc., for use in connection with the new and improved machinery, which is usually installed. Ordinarily the problem of perfecting the organization when entering new and larger shops is such that little attention can be given to this subject. In order to get the best results it is necessary to have a capable man give his entire time and attention to it, and he should be given the necessary help to assist him in making drawings and the improvements required. The foremen are usually depended upon to get up these devices and improvements in addition to their own work, but the constant interruption and the continual call for their presence in other parts of the shop, as well as the large amount of routine work which they have to handle, prevents them gaining much headway unless it is done out of hours. It is interesting to note that some of the larger shop plants are overcoming this difficulty by placing the matter of care and maintenance of the machine tools and the question of improving their output in the hands of a capable man and giving him sufficient assistance to carry out his ideas. In one large shop this man, who reports directly to the shop superintendent, has two good draughtsmen under him, and in another large plant all the engineering problems connected with the shop maintenance and operation are in charge of a man who reports directly to the shop superintendent and has sufficient help to assist him in carrying out this work and improving the production.

ELECTRIFICATION OF A STEAM RAILROAD.

The first extensive change of the motive power on a surface railroad from steam locomotives to electricity is being made by the Long Island Railroad Company, which is now running a considerable number of electric trains, and is increasing the number as rapidly as possible. It is expected that within a very short time all lines where the traffic is of sufficient density will be electrified, and steam locomotives will be used only where an infrequent train service is required.

This railroad occupies a unique position as compared with other steam railroads, in that the traffic is so predominantly passenger, the passenger train mileage being about eight times the freight train mileage, where ordinarily the two are equal. This, coupled with the fact that the density of passenger traffic on this road is enormous, being nearly 47,000 passengers carried per mile of track as compared with about 6,000 for the whole of New York State, including the Long Island Railroad, and about 2,500 for the whole country. Also, the average haul per passenger (about 14½ miles) is less than half the average for the whole country and 50 per cent. less than the average for New York State. These facts show conditions which are particularly well adapted for the advantages of electric traction. However, taken together, the conditions presented here are not incomparable with the strictly suburban sections of many other railroads, and what has been done by the Long Island is interesting as illustrating one method of solving a problem which several companies will soon have to face.

In the May issue of this journal appeared a very complete description of the large power house which furnishes the current for operating the trains, and elsewhere in this issue is given a brief general description of the transmission line and sub-stations. Our next issue will contain an illustrated article on the all-steel passenger cars being operated over the electrified portions of the road.

MASTER MECHANICS' ASSOCIATION.

39TH ANNUAL CONVENTION.

TOPICAL DISCUSSIONS.*

IS NOT A BOILER PRESSURE OF 185 LBS. BETTER THAN 200 LBS. FOR LOCOMOTIVES?—Dr. W. F. M. Goss opened this subject as follows: "I assume that the question which is asked applies to simple locomotives using saturated steam; also that the question applies to proposed locomotives; that is, that I may discuss it as a question of design rather than a question of expediency controlling the operation of existing engines. Since the beginning of practice involving locomotives the steam pressure has steadily increased. I have taken from a paper by Mr. William Forsyth, published some time ago in the *Engineering Magazine*, a diagram showing the progress in steam pressure, with the years. On this diagram the 100-lb. limit was passed between 1860 and 1870; the 160-lb. limit was passed in 1890; the 200-lb. limit was exceeded in certain cases in 1900, and the tendency of the curve is still upward. In view of this history it is of importance to ask whether the limit of pressure has been reached; or, to word the question as it has been worded for me, as to whether the limit has not already been passed. As a preliminary to a more detailed discussion of the subject, I would call attention to the fact that as a problem in design the question of steam pressure does not directly affect the question of power. It is a common mistake to assume that a locomotive carrying an abnormally high steam pressure must be abnormally powerful. Of course, those of you who have studied the problem understand that that need not be so, since the power which the locomotive develops is represented by the stresses which are transmitted by the piston rods, and these stresses are as much a function of the cylinder volume as of the steam pressure. Consequently, having selected our steam pressure, we may determine the volume of cylinders for any power which is within the capacity of the other proportions of the locomotive. The thing which I emphasize is, then, that the question of power is not related to that of pressure as a problem in design, except in so far as pressure may effect efficiency."

"This leads us, then, to a consideration of the question: to what extent will increase in pressure improve the cylinder performance of a locomotive? I believe that a general view of the facts involved in this question may most easily be apprehended by referring to the performance of the ideally perfect engine, and for this reason I have given upon Diagram 2 as the curve A B the steam consumption per horse-power hour of an engine ideally perfect, using steam at various pressures and exhausting at a pressure of 5 lbs. above atmosphere. From this diagram you will see that beginning with a pressure of 25 lbs. the steam consumption per hourse-power hour of this perfect engine is 40 lbs., and that the steam consumption diminishes rapidly as the pressure is increased until the pressures become considerable. For the higher ranges of pressure the increase in performance is very slight. For example, if you will scan the upper portion of that curve you will note that from 175 lbs. to 275 lbs. the inclination of the line is very slight. The performance at the higher pressure is but slightly better than that at 175 lbs. From this statement it appears that from theoretical considerations alone we should not expect any large improvement in the efficiency of the locomotive by merely increasing pressure."

"Turning now to an experimental side of the question, and considering what the actual performance of a locomotive may be when served with pressures of different values, I present to you the line C D, which fairly represents a series of more than 70 tests, all under pressures ranging from 120 to 250 lbs. per sq. in., and which have been conducted under the patronage of the Carnegie Institution. This curve C D fairly represents these 70 tests, showing the steam consumption per horse-power hour for the several pressures given. I call your attention also to the form of this curve. Its upper portion you will see is almost vertical. The change in performance when the pressure is increased from 175 lbs. to 250 lbs. amounts only to 1.3 lbs. of steam per horse-power hour. Moreover, I would add that these curves are plotted as shown, in terms of steam per horse-power hour, inasmuch as at the higher pressures a pound of steam represents more heat than

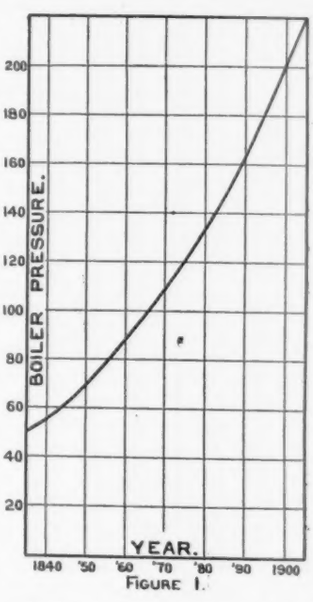


FIGURE 1.

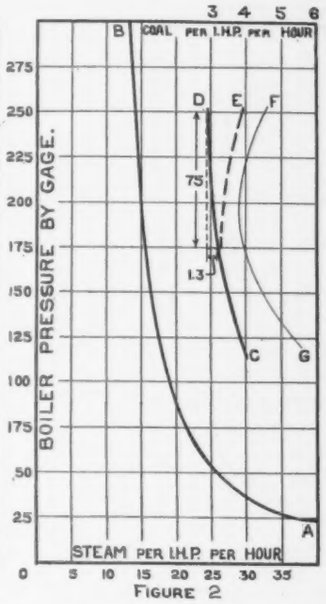


FIGURE 2

at the lower pressure. If the plottings were made upon a heat basis alone, these lines would be even more nearly vertical than they are shown."

"The results which are represented by line C D are obtained in return for great vigilance in the maintenance of boiler and engine. Small leaks occur, especially at the higher pressures, which, while they may attract but little attention, become the source of serious losses. These leaks and the effect which they have upon cylinder performance are more difficult to deal with as the range of pressure increases, so that if we take an actual engine working under conditions of service, the actual performance, as measured by steam per horse-power hour, is likely to take some other curve; not the curve C D, but some curve which may be C E. That is, the expected gain when the pressure is increased actually becomes a loss through incidental causes, chiefly through leaks."

"Of course, the problem of coal consumption per horse-power hour is, after all, that which we are after. I cannot present to you any curve of coal consumption which will be as representative as that which I have given for steam consumption, since the data covering coal performance is not yet in hand; but I do present to you a curve which I have lettered F G, which represents one series of tests. All the tests which were made were made with a given cut-off, about ¼ stroke—perhaps 15 or 18 tests altogether—and you will note that on the basis of coal consumption as determined from these few tests we have the minimum consumption at a pressure not greater, at any rate, than 200 lbs., and when the pressure is increased above that limit the coal consumption increases. The values to which the curve F G refers are given at the top of the diagram."

"This presents to you in rather brief form the performance of a single actual engine as regards cylinder performance and coal consumption. I must call your attention to the fact that this is not a fair and full statement of all of the problems involved, because of the fact that the tests here were run at comparatively low pressures, with a boiler which was designed for 250 lbs. pressure. That is, it was lower than a high-pressure boiler."

"Suppose, now, instead of proceeding, as has been done with these experiments, there had been a new boiler available for

*Continued from last month

each of these different pressures, which boilers would be constant in weight, but those which were designed for low pressures would be made enough larger in their heating surface to maintain their weight; that is, suppose in this record we had taken advantage of the opportunities which the selection of lower pressure would give for increasing the size of the boiler. It would then appear that all of these lines would show a lower steam consumption and a lower coal consumption, as we go downward. That is, the upper end of these lines would at once move to the right, showing that the point of minimum consumption would be lower than the points which are shown by them, and as a problem in design, of course, it is that view which must in the end prevail."

"Summarizing the statements already made, and adding others thereto, the following will be found to be true:

(1) Very high steam pressures are not essential to the development of high power.

(2) The advantages to be obtained from an increase of pressure above any given limit are only such as may be derived from an improvement in cylinder performance, and from a reduction in the dimensions of cylinders. For all increments of pressure above 150 lbs., the possible improvement in cylinder performance will be small; above 185 lbs. it is practically negligible. As to cylinders, it may be noted that conditions external to the locomotive may sometimes require the use of abnormally small cylinders, but such conditions will not often be a controlling factor. It is true also that small cylinders permit the use of lighter pistons, and hence they tend to simplify the problem of counterbalancing."

(3) The disadvantages to be met when the pressure is increased above any given limit are as follows:

(a) An increased weight of boiler for a given amount of heating surface; or when the designer is required to observe weight limits, less heating surface than might otherwise be used, and hence a boiler of lower efficiency.

(b) Where feed water is of poor quality it increases the difficulty attending the maintenance in working condition of injectors and boiler checks.

(c) It complicates the problem of keeping boilers tight and in general adds enormously to the cost of boiler maintenance.

(d) It increases incidental losses, especially those occurring in the form of leaks of steam or water from boiler and cylinders."

"From these considerations it appears that a general solution of the problem of determining what is the most economical pressure for a locomotive involves three sets of facts:

(1) Those defining cylinder and boiler performance. (2) Those dealing with the weight of boilers designed for different pressures and different capacities. (3) The degree of perfection with which the locomotives are to be maintained in service."

"An abundance of data covering the first two of these points is now in hand, while the third probably can never be absolutely defined."

"I may say that during the summer it is expected that an analysis based upon this data to which I have referred will be made, and I am hoping that by fall I shall be able to add to this discussion something that will be more conclusive than that which I give now. Meantime, I can only say, in response to the specific question which has been assigned me, that my investigations justify the assertion that a pressure of 185 lbs. will give better results in a simple locomotive using saturated steam than would be obtained from a pressure of 200 lbs."

THE NECESSITY OF PROPORTIONING BRAKE PRESSURES TO WHEEL LOADS.—Mr. George L. Fowler opened this discussion, and mentioned the fact that the M. C. B. Association had expressed itself as being opposed to changing the brake pressure in light and loaded cars. This action he considered to apply to ordinary merchandise service under present conditions. He thought, however, since a car of 110,000 lbs. capacity with the present arrangement was braked to only about 17 per cent. of its weight, that certain cars in special service could be advantageously fitted with an arrangement for increasing the brake pressure when the car was loaded. In case such an arrangement was automatic it would be better to have it operate in only one direction; that is, to have it cut out when the car was light. He considered that for coal or ore trains, and possibly cattle trains running in regular service, such a device would be exceedingly valuable. This could be cut in when the car was loaded at the terminal, and would be automatically cut out when it was empty.

THE DISTORTION OF WHEEL CENTERS AND TIRES OUT OF ROUND, DUE TO HEAVY COUNTERBALANCE ON 100-TON ENGINES.—Mr. George W. West opened the discussion, and spoke of his experience with some 100-ton engines which were very satisfactory riding locomotives until the tires had worn down to about 2¼ ins. thick, when they began to ride very hard, due to the tires being out of round. Later it was found in attempting to apply tires to the same wheel centers, which were of cast steel, without truing them up, that the centers were also out of round. It was found, upon testing, that the wheel was compressed between the counterbalance and the hub from 1-32 to 3-32 of an inch. He thought this to be due to poor design.

TO WHAT EXTENT SHOULD AN ENGINE BE REPAIRED IN THE MAIN SHOP, AND WHAT CLASS OF REPAIRS COULD BE MADE TO ADVANTAGE IN THE ROUNDHOUSE?—Mr. C. A. Seley stated that it was a general custom when engines go into the main shop for general repairs to completely dismantle them. He did not think that this was always necessary, and that there were certain parts in a locomotive which could better remain as they were, mentioning as examples the injector, cylinder lubricator, cocks and valves in the cab, pumps, cylinder and valve packing. These parts are in most cases maintained in satisfactory shape by the roundhouse forces, and it is not necessary to take them down in the main shop. He considers that a large saving could be made by close attention in the shop, so that no unnecessary work would be done.

Mr. G. R. Henderson spoke of the card system, by which each engine is assigned a card when it goes to the shop, on which the cost of repairs and their general nature is stated in detail. This card was filed, and the next time the engine was sent to the shop the card giving an account of what repairs had previously been made, which compared with the mileage the engine had made since that shopping, gave indication of what work would be required.

RELATIVE ADVANTAGE OF A PISTON VALVE AS COMPARED TO A SLIDE VALVE.—Mr. E. A. Miller (N. Y. C. & St. L.) opened the discussion, and gave the results of quite a large number of tests made to show the difference in leakage past the rings of slide and piston valves. Some of these tests showed that the slide valves caused more leakage. The general conclusion which he drew, however, from the different series of tests was that the piston valve gave more leakage than a balanced slide valve.

Mr. William McIntosh stated his experience to the effect that piston valves would need careful attention and occasional refitting, in order to prevent excessive leakage.

Mr. J. F. Walsh stated that he had applied piston valves to a large number of engines, principally on account of the easier handling in switching. He stated that his piston valve engines had given little trouble from leakage or in other respects, and that he thought there was so much in favor of the piston valve as against the D valve that there is but little room for argument as to which is best.

Mr. John Player called attention to the fact that because of the increased length of the ports in a piston valve engine, the comparative measure of the leakage should not be taken as the measure of the efficiency of the valve.

Mr. John H. Pilcher (N. & W.) stated that, while the tests quoted from his road showed that the piston valve leaked less than the slide valve, that experiments on the road would seem to indicate otherwise; they were, however, applying piston valves to new power.

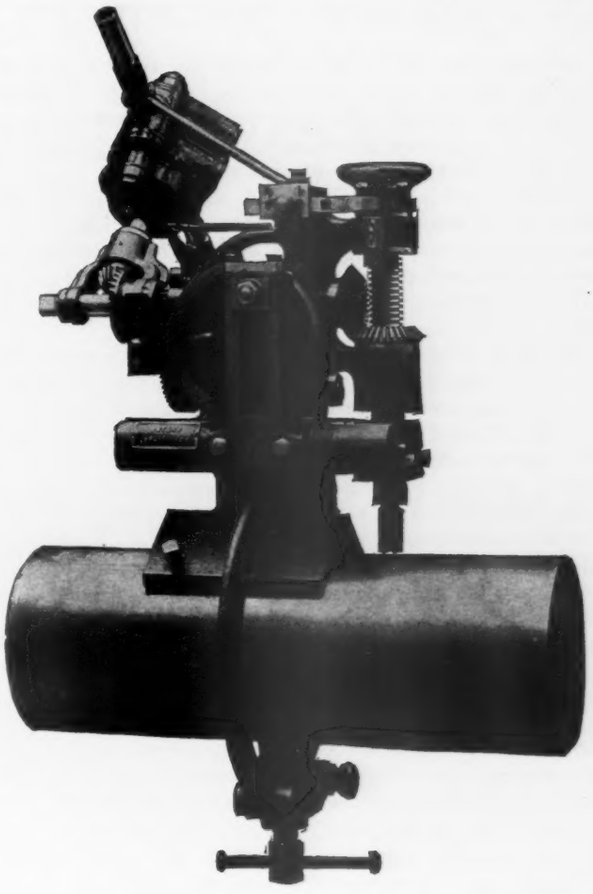
Mr. S. T. Parks (M. C.) brought up the point of the engineer not being able to tell if the piston valve was being properly lubricated, and recounted some tests which he had made, showing that a dry piston valve gave practicaally no indication upon the reverse lever.

PORTABLE KEY-SEATING MACHINE.

A light-weight machine which will automatically mill the key-seat in a locomotive driving axle or a shop line shaft has recently been placed upon the market by Joseph T. Ryerson & Son, Chicago. This machine, which is illustrated herewith, is driven by a small size air motor, which, through the proper gearing, operates a milling cutter for milling the key-seat. It is so arranged that it can be set for any desired length and depth of seat, and will work automatically. The construction is substantial, but so carefully designed that the whole machine weighs but 100 lbs., and can be easily located and set by one man.

This machine is particularly adapted for milling key-ways in driving axles after the locomotive is assembled, and is so constructed that it can mill a key-way to within one inch of the driving box. It has a particular field of usefulness in milling new key-ways in axles after a locomotive has been repaired and changes made in the location of the eccentrics, such as ordinarily require the use of an offset key, which is objectionable from all points of view. It will, we believe, cover a field which has long been a source of annoyance and delay to master mechanics.

One of these machines was shown in operation at the Atlantic City conventions by the manufacturers, where it illustrated its capabilities very clearly.



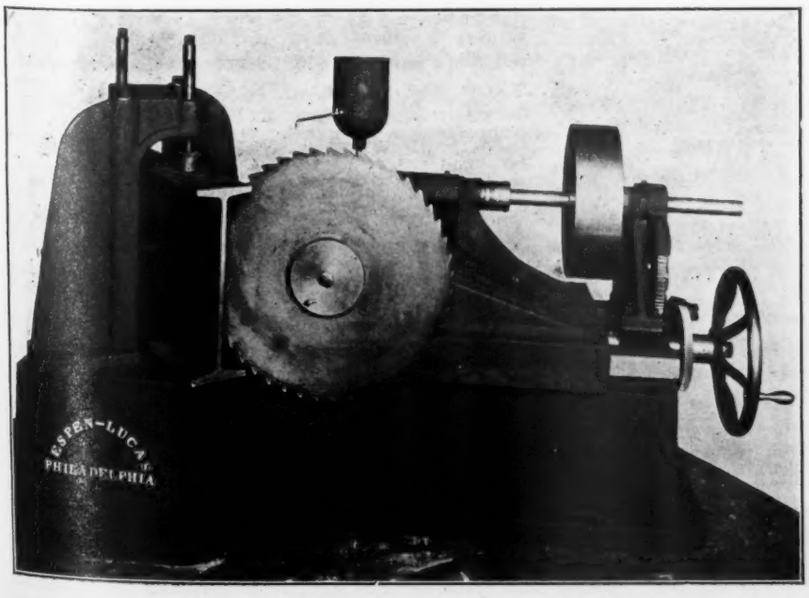
KEY-SEATING MACHINE.

ESPEN-LUCAS COLD SAWS.

A cold saw cutting-off machine, which has a capacity for cutting structural material up to 20-in. I beams, has recently been placed on the market by the Espen-Lucas Machine Works, Broad and Noble streets, Philadelphia, and is illustrated herewith.

This machine has two swiveled clamps for holding the work which can be adjusted to hold the beam or other material to be cut, either at an angle, as shown in the illustration, or for a straight cut, in which case both clamps are on the same side of the work and spaced suitably to hold both sections of the cut beam. The saw blade, which can be either the solid blade or with high-speed steel inserted teeth, is driven through a worm gear from a belt connection. The worm is of hardened crucible steel and the worm wheel of phosphor bronze. The heavy gears for driving the saw are of hammered crucible steel cut from the solid. The feed is variable and automatic, and can be increased or decreased as desired while the machine is cutting. An automatic stop is provided for throwing out the feed at any desired depth of cut.

The capacity of the machine illustrated is 20-in. I beams or 9-in. solid bars, and the floor space occupied is 40 by 80 ins. The machine weighs 7,000 lbs.



ESPEN-LUCAS COLD SAW.

EXCELLENT RECORD OF THE PENNSYLVANIA SPECIAL.—The record for the first year's service of the 18-hour "Pennsylvania Special" between New York and Chicago, which began running on June 11th, 1905, is now at hand, and shows that during the 365 days' service this train arrived late at Jersey City but 54 times and at Chicago but 37 times. The equipment of the train caused delay 17 times during the year to the eastbound train and 14 times to the westbound train. The remainder of the delays were due to various road causes.

TRAVELING ENGINEERS' ASSOCIATION.—The fourteenth annual convention of this association will be held at the Auditorium Hotel, Chicago, commencing on August 28, and will probably continue over four days. W. O. Thompson, Oswego, N. Y., is secretary.

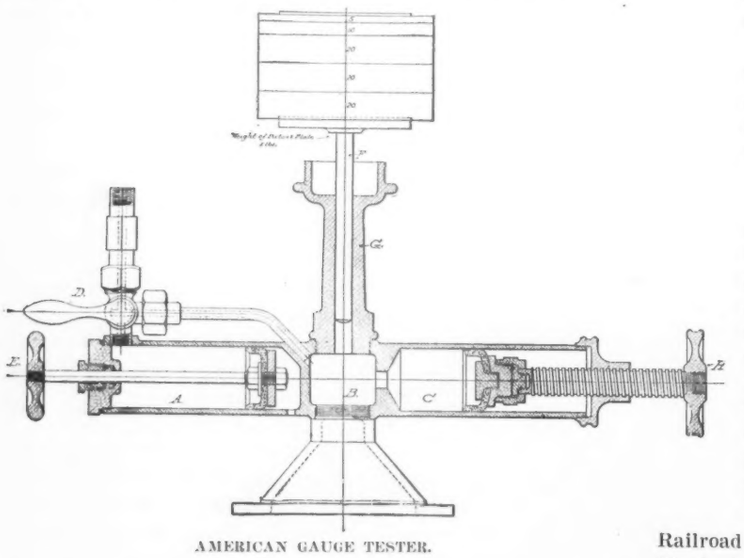
AMERICAN DEAD WEIGHT TESTER.

The necessity for having accurate and reliable apparatus for checking and testing pressure gauges is easily recognized. The common method of having a test gauge, which it is necessary to have checked by an absolutely accurate pressure test at various times in order to insure its reliability, has its disadvantages, and to overcome such objections the American Steam Gauge & Valve Manufacturing Company, Boston, Mass., has recently put on the market a dead weight tester for pressure gauges which can be relied upon for absolute accuracy at all times and does not require checking by any other apparatus.

This dead weight tester is shown in section herewith, and it can be seen that the pressure upon the gauge is obtained by the actual pressure given by weights, and hence is positive and accurate. The instrument is made in very compact and convenient form, and is constructed with the idea of convenience and simplicty as well as accuracy.

The principal parts of the apparatus are a chamber B, which is directly connected to the cylinder G, in which a small piston, F, operates. The area of this piston is very carefully figured, and the weights placed on the stand above are of the proper weight to give the pressure per square inch marked on them. The gauge is also connected to this chamber through a short section of piping, which passes through a three-way valve on its way to the gauge. The chamber, A, which has no direct connection with B, is used as an oil reservoir for storing the oil required to fill the connection between the valve and the gauge. It has a plunger operated by a handle. The chamber C has a screw plunger, whose office is to raise the piston F under weight after the gauge is in place. The whole apparatus is mounted on a wooden base, and is polished and finished in a suitable manner.

The operation of the tester is as follows: After the chambers A, B and C are filled with a light mineral oil, and the gauge to be tested is screwed in place, the handle of the three-way cock D is turned to give connection to the chamber



AMERICAN GAUGE TESTER.

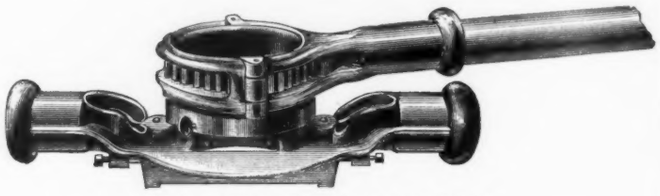
A, then the plunger E is pulled outward until the gauge shows some pressure indicating that the connections are filled with oil. The three-way cock D is then turned, closing the connection to chamber A and opening it to chamber B. The weights corresponding to the pressure desired, less 5 lbs. furnished by the stand and piston, are placed on the stand, and the screw plunger in C is forced inward until the pressure acting on the piston F raises the weights, at which time the gauge will, if properly adjusted, show the pressure indicated by the weights. The screw plunger can be turned so as to raise the weight piston up and down, thus eliminating any chance of error by its sticking in the cylinder.

After testing and before disconnecting the gauge the handle E is pushed inward and the three-way cock D turned to allow the oil from the gauge connections to be collected in the chamber A, thus preventing the loss of any oil during the testing.

A RATCHET ATTACHMENT FOR DIE STOCKS.

The frequent necessity for doing pipe work and for making alterations and repairs to piping in close and cramped quarters has brought several ratchet die stocks on the market. These usually require that the buyer purchase a complete stock in order to avail himself of the ratchet.

The Armstrong Manufacturing Company, Bridgeport, Conn., however, recently perfected ratchet attachments fitting their various sizes of stocks, which are easily attached to or removed from the stock by simply removing a thumb screw.



RATCHET ATTACHMENT FOR DIE STOCKS.

This allows the pipe-fitter to use the regular Armstrong stock on ordinary work, and have only the added weight of the ratchet, in cases where it is necessary to thread the pipe in confined space, such as in ditches or where the pipe runs near a wall or ceiling.

The Armstrong ratchet consists in a light but strong malleable iron ring, which carries the ratchet and pawl, and which is slipped over the barrel of the stock and securely attached to it by a thumb screw. No extra handle is provided as the extension is tapped to receive one of the stock handles. It may be adjusted for turning the stock in either direction.

This is a strong and thoroughly reliable tool that has proved of great service and value to pipe fitters and engineers, enabling them to use regular Armstrong stocks for threading pipe in positions where otherwise they would have to take down the pipe.

INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION.—The fourteenth annual convention of this association will be held at the Sherman House, Chicago, commencing on August 21, and will be in session for three days. Committee reports on the following subjects will be presented and discussed: "Frogs and Crossings," S. Uren, chairman; "Flue Welding—Best Method of Flue Welding and Flue Used," G. H. Judy, chairman; "Classification of Work in Shop," W. J. Mayer, chairman; "Tools and Formers for Bulldozers, Steam Hammers and Forging Machines," Thomas F. Keane, chairman; "Discipline, and How to Obtain the Best Results in a Railroad Blacksmith Shop," A. W. McCaslin, chairman; "Case Hardening Methods—Time Taken and Specimens of Work Furnished, and Kind of Material Used," G. F. Hinkins, chairman; "Best Method of Annealing High-Speed Steel, Also of Tempering," George Lindsay, chairman; "Best Coal for Use in Smith Shop and Kind of Fires Used," John Buckley, chairman; "Subjects for 1907 Meeting," G. H. Judy, chairman; "Piece Work vs. Day Work," R. A. Mould, chairman; "Making of Locomotive Frames—From Scrap to Finish, Also Repairing—How Many Broken During the Year—How Often Broken in Same Place," James Fenwick, chairman; "Thermit Welding and Cost," George Kelly, chairman. All motive power officials and foremen blacksmiths are cordially invited to attend, whether members of the Association or not.

MASTER CAR BUILDER'S ASSOCIATION.

ABSTRACTS OF REPORTS.

(*Continued from page* 288.)

CAST IRON WHEELS.

Committee.—Wm. Garstang, Chairman; A. S. Vogt, H. J. Small, W. E. Fowler, R. L. Ettinger, J. J. Hennessey, J. E. Muhlfeld.

As instructed, we were able to arrange a conference with the American Railway Association, through a committee appointed by President Fish, with Mr. G. L. Peck as chairman, the instructions to Mr. Peck's committee being to consider a standard cast iron wheel and rail section. The personnel of this committee was as follows: Mr. J. T. Richards, C. E., Pennsylvania Railroad; Mr. J. Kruttschnitt, director of maintenance and operation, Southern Pacific; W. J. Wilgus, vice-president, New York Central; R. Montford, consulting engineer, Louisville & Nashville; E. C. Carter, C. E., Chicago & Northwestern; William Garstang, superintendent motive power, Big Four; R. L. Ettenger, consulting mechanical engineer, Southern; W. E. Fowler, master car builder, Canadian Pacific.

This committee held a meeting on April 24 at Chicago, and another meeting on June 12, at Atlantic City. At the Chicago meeting, the present Master Car Builders' standard wheel was presented with the flange increased ⅛ in. on the inside.

The maintenance of way members, after taking the matter under advisement, reported at the Atlantic City meeting that the thickness of flange might be used with present track conditions without detriment to frogs or crossings, and to put the opinion of his committee before the Master Car Builders' Association, so that some action can be taken at this convention, Mr. G. L. Peck, chairman, has handed us the following letter:

"The question as to whether the proposed increase of ⅛ in. in the thickness of flange of cast iron wheel would make it necessary to increase the clearance at frogs and guard rails, was considered by the committee on Standard Rail and Wheel Sections of the American Railway Association, at its meeting in Atlantic City to-day.

"The committee decided unanimously that a wheel of the section submitted by your committee could be run through the present clearances without difficulty, for, while the increase in thickness amounts to ⅛ in. at the point where you measure the flange, we find that the increased thickness at the point of gauge for track is not more than 1-32 in., or an amount almost negligible.

"The committee, of course, will not be prepared to adopt or recommend a standard cast iron wheel in all its features until after hearing from the Master Car Builders, but in view of the fact that the flange matter may be considered somewhat of an emergency, the committee will be prepared to recommend an increase in the thickness of the flange to the American Railway Association, so that action may be taken by that body at its meeting in October next.

(Signed) "G. L. PECK, Chairman."

Your committee, therefore, asks that action be taken during this convention that will enable the American Railway Association to have our recommendations before them at their October meeting, and we submit for approval the following changes in the present standard wheel: An increase of ⅛ in. on the flange, and a change in the taper of the tread from one in twenty-five to one in twenty. The reason for asking for the change in the taper is due to experiments that have recently been made which indicate less flange wear and a longer life to the wheel on this account.

We also ask that the specifications be changed so that the minimum weight be 600, 650 and 700 lbs. This is necessary because the increase in the flange will add about 15 lbs. to the present standard wheel. Your committee feels that these are the only changes to recommend in the present wheel, and if allowed, will result in a design that will very largely eliminate flange failures.

Should the action of your committee meet with the approval of the association, we call attention to the necessity of revising the present mounting gauges to suit the increased wheel flange, and would suggest that this be taken up by a committee during the present year.

BRAKE SHOES.

Committee—W. F. M. Goss, chairman; William Garstang, George W. West.

Your standing committee on brake shoes, at a meeting held at Indianapolis October 10, 1905, agreed that some inquiry should be made to ascertain the frictional quality of the shoes now being supplied to railway companies in comparison with the specifications of the Association. To this end, at the request of your committee, a circular was issued by the secretary, requesting the railway companies to submit shoes for tests, shoes submitted to be taken from service after having been approximately one-third worn.

Under this arrangement a total of 109 shoes was received from nine different railway companies, two of the shipments, however, arriving too late to receive attention during the present year. [Of this number 16 representative shoes were tested.]

All shoes received were delivered to the engineering laboratory of Purdue University. The tests were made under the direction of the University, the work being in the immediate charge of Prof. W. O. Teague, who was assisted by Mr. L. E. Endsley, instructor in the engineering laboratory.

It had been requested that each shoe be marked with a statement of the service from which it had been taken. In cases where the accompanying statement showed that the shoe had been taken from freight service, it was tested upon a cast-iron wheel only; where the statement showed that it had been taken from passenger service, it was tested on a steel-tired wheel only, and where no statement as to service accompanied the shoe, it was tested on both cast-iron and steel-tired wheels.

The results disclosed the fact that of the fifteen shoes tested on the cast-iron wheel three completely met the specifications of the Association. Eleven of the fifteen met the specifications as to the mean coefficient of friction, but eight of this number exceeded the limits allowed at the end of the stop. Five shoes met the specifications as to the rise in the coefficient at the end of the stop. Of the nine shoes tested on the steel-tired wheel, all met the specifications as to the mean coefficient of friction during a stop, but all failed to meet the specifications as to rise in the coefficient of friction at the end of the stop.

Your committee would call attention to the fact that while the specifications provide for a minimum coefficient of friction they do not fix a maximum; also to the fact that at least two shoes which were tested possess frictional qualities which are far in excess of the minimum values specified. While a high coefficient of friction is, in the abstract, a desirable characteristic to be possessed by a brake shoe, operating conditions make uniformity of action desirable. For example, the records of the Association show that a large amount of attention has been bestowed upon the triple valve for the purpose of securing uniformity both in time and intensity of its action, that the surging of trains may be prevented. But the retarding force which is set up through the action of the brakes is as much a function of the frictional qualities of the brake shoes as of the action of the triple valve. Assuming all cars of a train to have the same brake leverage, and to be equipped with triple valves possessing identical characteristics, if the frictional qualities of the brake shoe are disregarded, that car which is fitted with shoes developing a high coefficient will tend to stop more quickly than an adjoining car having brake shoes possessing inferior frictional qualities. If variations in the coefficient of friction of brake shoes are allowed to become great, the surging of the several cars making up a train is likely to become severe. The extent of the variation in frictional qualities may best be seen by reference to Appendix I. A brief summary of this Appendix is as follows:

MEAN COEFFICIENT OF FRICTION DEVELOPED UPON A CAST-IRON WHEEL UNDER A BRAKE-SHOE PRESSURE OF 4,152 POUNDS.

Brake-Shoe Number.	Coefficient of Friction.	Coefficient of Friction at a Point 15 Feet from Stop.
Values provided for by the Specifications.	20.	7.
158	20.0	5.2
161	21.6	2.2
163	21.3	7.0
172	20.6	6.9
175	27.2	7.0
178	17.7	6.4
179	33.2	6.3
183	37.4	2.6
186	21.3	8.6
194	22.3	7.6
200	20.3	6.9
205	21.4	7.7
209	23.8	5.5
214	19.3	6.7
220	24.4	7.0

MEAN COEFFICIENT OF FRICTION DEVELOPED UPON A STEEL-TIRED WHEEL UNDER A BRAKE SHOE PRESSURE OF 4152 POUNDS.

Brake-Shoe Number.	Coefficient of Friction.	Coefficient of Friction at a Point 15 Feet from Stop.
Values provided for by the Specifications.	14	7
158	17.0	9.0
161	14.8	10.1
163	18.9	8.8
175	18.4	12.4
178	16.7	9.2
179	22.8	7.8
205	16.3	8.9
209	16.0	11.1
215	16.5	10.8

Thus far the standing committee on brake shoes has concerned itself with the frictional qualities of brake shoes. The question has often been raised as to whether it would not be practicable for your committee to test the wearing qualities of brake shoes. Response to inquiries of this kind has uniformly been made to the effect that the processes of the laboratory proceed too slowly to permit such tests to be made, and those inquiring have been referred to road tests as the readiest means of determining the endurance of shoes. Your committee is, however, convinced that many interests would be served if manufacturers, in submitting shoes for test, could be given a statement covering wearing qualities, as well as a statement covering coefficient of friction. It is also possible that if a satisfactory test could be formulated, specifications covering wearing qualities might be framed.

In its consideration of this matter your committee has reached the conclusion that such tests are possible provided some additional mechanism could be attached to the testing machine. The purpose of the proposed addition to the testing machine would be to permit a shoe to be brought in contact with the wheel of the testing machine for a predetermined interval, after which it would be automatically raised from the wheel and remain in released position

for another and a much longer interval, after which it would again automatically make contact with the wheel. It is believed that by such a cycle any shoe could be given a definite amount of exposure to wear, and that by the automatic action of the machine in alternately making the application and release all chances of excessive heating would be avoided.

In following up the matter your committee was fortunate in securing the interest and assistance of Mr. Fritz Ernest, instructor in car and locomotive design, Purdue University, who undertook a study of the problem, with the result that the details of a satisfactory mechanism have been designed. A description and drawings of the proposed mechanism are given as Appendix II. The cost of making the proposed additions will be between $300 and $400.

Among others who have given assistance in the work of the year your committee would especially acknowledge the courtesy of the Griffin Wheel Company in supplying for the brake-shoe testing machine three specially bored and fitted cast-iron wheels.

In conclusion, to summarize its report, your committee would call attention to the following matters:

1. That shoes taken from service have in most cases met the requirements of the Association with reference to the mean coefficient of friction to be developed during a stop.
2. That shoes taken from service have in most cases failed to meet the requirements of the Association with reference to the rise in the coefficient of friction at a point 15 feet from the end of the stop.
3. That shoes are now in service which give a coefficient of friction so much in excess of the minimum specified as to permit great variation in braking effect. The logic of the situation would seem to require, either that the present specification be raised, or that a maximum coefficient as well as a minimum be specified.
4. That it would be well to equip the Association's testing machine for determining the wearing qualities as well as the frictional qualities of brake shoes, and to this end we would recommend that the question of proceeding with the construction of such equipment be referred to the executive committee.

Air-Brake Hose Specifications.

Committee—Le Grand Parish, chairman; J. Millikin, T. S. Lloyd, R. L. Ettinger.

In submitting the air-brake hose report from the engineering laboratory of Purdue University, your committee arrived at the following conclusions:

1. It thinks in time that a chemical standard should be set for the rubber in the tubes and friction. It is believed at the present time that the physical tests which are now the standard of the Association are not conclusive, and from information which has been brought to the attention of the committee during the past year, your committee believes that the government chemists and superintendents of tests, and the chemists of some of the large corporations, have now arrived at a point in connection with tests of rubber where they are able to determine within a very small per cent. the amount of shoddy or substitute which is being used to adulterate the pure gum.
2. It believes that in time the bursting pressure and chemical analysis of the rubber and grade of duck should make up the specifications. In order to do this your committee would recommend that a committee composed of several of the railroad chemists give the matter of chemical analysis a thorough investigation with a view of making a report to the Association.
3. The life of the air-brake hose depends upon the purity of the rubber. This conclusion is arrived at from a study of the report, which shows plainly the rapid deterioration of the inner and outer tubes.
4. Your committee is satisfied, from a careful study of the stretching test, that a physical test will not give any idea of the life of the hose. This leads to the conclusion that it is possible to develop a system of ageing the hose by some thermal or chemical method, which will give a general idea of what the condition of the rubber would be after various periods of service. This will eliminate a great deal of the uncertainty of determinng the cause of the failure.

Your committee feels that we should call attention to the mechanical conditions which bring about failure in air-brake hose. Observations lead to the belief that very little advance has been made in eliminating the cause of this damage. The committee has had presented to it a report from one of the prominent railroads, which shows conclusively the fact that 85 to 90 per cent. of the failures may be attributed to external or mechanical causes, and cannot be said to be due in any way to the quality of hose.

It is a well-known fact that some roads are now using a cheap hose, and thus getting a low cost per car per year. The committee feels that this is not the only thought to be considered, but that safety of trains, passengers' lives, and the tremendous cost on account of wrecks, must not be lost sight of.

Your committee herewith presents a specification for woven and combination wrapped and woven air-brake hose for the consideration of the Association. In submitting this specification your committee has had in mind the necessity of having it in line with the present wrapped hose specification.

It is believed that the tensile test will be valuable in determining the quality of the rubber.

Specifications for Woven and Combination Wrapped and Woven Air-Brake Hose.

All air-brake hose under this specification is to consist of not less than three plies of woven, braided or knitted fabric, or of two or more plies of canvas wrapping surrounded by at least one ply of woven, braided or knitted fabric. The hose should be flexible without kinking easily. The rubber, fabric or duck should be the best of its kind made for the purpose, and no rubber substitute or short fibre will be allowed.

The inner tubes should be composed of three calenders of rubber and not less than 3-32 in. thick at any point. Should a machine-made tube be used, it must not be less than ⅛ in. thick at any point. It must be free from holes and imperfections, and in joining it must be so firmly united to the cotton fabric that it cannot be separated without breaking or splitting the tube. Each ply of the hose should be separated by a distinct layer of rubber, and over this is to be a cover 1-16 in. thick and at each end a 1-16-in. cap should be vulcanized on, the cover and the cap to be of the same material as the inner tube.

The hose is to be furnished in 22-in. lengths, and variations exceeding ¼ in. from this length will not be permitted. The rubber caps at each end are not to be less than 1-16 in. nor more than ⅛ in. thick. The inside diameter of the hose must not be less than 1⅜ ins. nor more than 1 7-16 ins., nor must the outside diameter be less than 2 1-32 ins. nor greater than 2 3-32 ins. The hose must be smooth and regular in size throughout its entire length.

Each hose must have vulcanized to it a badge of white or red rubber as shown; on the top of the badge the name of the purchaser, on the bottom the maker's name, on the left-hand end the month and year of manufacture, and on the right-hand end the serial number and the letters "M. C. B. Standard." The letters and figures must be clear and distinct, not less than 3-16 in. in height, and stand in relief not less than 1-32 inch, so they can be removed by cutting without endangering the cover. Each hose must also have vulcanized to it a badge of rubber showing the copyright, as shown.

Each lot of 200 or less must bear the manufacturer's serial number, commencing at "1" on the first of the year and continuing consecutively until the end of the year, and the serial number should not be duplicated, even though the hose bearing the original numbers be rejected. For each lot of 200, one extra hose must be furnished free of cost.

Tests to Which Samples Will Be Subjected.

Bursting Test.—All hose selected for test will have a section 5 ins. long cut from one end and the remaining 17 ins. will then be subjected to a hydraulic pressure of 400 lbs. per sq. in. for ten minutes, which it must stand without failure. At a pressure of 100 lbs. per sq. in. it must not expand more than ¼ in. in diameter or change in length more than ¼ in., nor develop any small leaks or defects.

Friction Test.—A section 1 in. long will be taken from the 5-in. piece previously cut off, and the quality determined by suspending a 20-lb. weight to the separated end, the force being applied radially, and the time of unwinding must not exceed 8 ins. in ten minutes.

Stretching Test.—Another section 1 in. long will be cut from the balance of the 5-in. piece, and the inner tube or lining will be separated from the ply and cut at the lap. Marks 2 ins. apart will be placed on this section, and then the section will be quickly stretched until the marks are 8 ins. apart and immediately released. The section will then be re-marked as at first, and stretched to 8 ins., and will remain so stretched ten minutes. It will then be released, and ten minutes later the distance between the marks last applied will be measured. In no case must the test piece break or show a permanent elongation of more than ¼ in. between the marks last applied. One-in. strips will also be taken from the cover and will be subjected to the same test.

Tensile Test.—Another section 1 in. long will be cut from the remainder of the 5-in. piece, and the rubber tube or lining will be separated from the ply and cut at the lap. It will then be reduced in the middle for a distance of 2 ins. by ½ in. wide parallel. The parallel section shall be spread to the full width of 1 in. at the end by curves of ½-in. radius. This specimen shall be stretched uniformly by gripping the enlarged ends, and in no case should the tensile strength per square inch be less than 400 lbs., nor the elongation at the time of failure less than 8 ins., measured by marks placed originally 2 ins. apart before breaking.

If the test hose fails to meet the required tests the lot from which it was taken may be rejected without further examination and returned to the manufacturer, who shall pay the freight charges in both directions. If the test hose is satisfactory, the entire lot will be examined, and those complying with the specifications will be accepted.

Triple Valve Tests.

Committee—A. J. Cota, chairman; T. W. Demarest, E. W. Pratt, F. H. Scheffer, F. W. Brazier.

During the past year a triple valve containing new features has been placed on the market by the Westinghouse Air Brake Company, and this valve in two sizes was submitted to your committee for test.

This valve, which is designed for freight equipment, contains three principal features not found in valves previously tested for the Master Car Builders' Association. They are as follows:

First, a quick service application.
Second, a retarded release.
Third, a retarded recharge.

Several of the tables accompanying this report show the circumstances and conditions under which these features will obtain.

The two sizes of this valve are designated as K-1 for 8-in. cylinders and K-2 for 10-in. cylinders.

The Westinghouse Air Brake Company has, for some time, furnished a triple valve designated as H-49 for 10-in. brake cylinders. This valve is similar in design to the F-36 valve and only differs from the latter in the capacity of handling larger volumes of air. No previous tests of the H-49 valve have been made by an M. C. B. committee.

Your committee expected that an entirely new type of triple would be submitted for test on the Purdue rack and arrangements

were completed for making these tests. However, at the last moment the manufacturers withdrew from the test, intimating that a test of 50 cars was not satisfactory and stating that if the M. C. B. requirements were changed from 50 to 80, 90 or even 100 cars, they would be glad to turn their valve over to the committee for test. This communication was received too late for your committee to make arrangements for conducting the test on a 100-car rack.

Your committee fully appreciates the fact that a 50-car test as provided for in the M. C. B. code, does not develop the conditions that must be met in handling trains of 80 or more cars.

The Westinghouse Air Brake Company in offering its new type of triple for test, stated that these valves would materially improve the operation of brakes on trains of 50 cars or less and were especially designed to meet the conditions which develop in handling trains of 80 or more cars. This company also stated that there was little to be gained by making a 50-car test and they would prefer making a test of 75 or 100 cars. Your committee advised the Westinghouse Air Brake Company that the testing rack at Purdue could not be used for more than a 50-car test. The Westinghouse Air Brake Company then offered your committee the use of either one or both of its 100-car test racks at Wilmerding. This offer was accepted with the understanding that your committee should have the exclusive use of the rooms, with the privilege of using either rack for testing triple valves manufactured by other companies.

Your committee arranged to make test on April 5, 6 and 7 1906, and invited the Air Brakes Association to appoint a committee to assist in making tests.

It will be noted by the test records, Appendix II, that all application tests were made with an 8-inch piston travel, while the code specifies 4, 6 and 12 in. piston travel. Your committee found that an 8-in. piston travel more nearly approximated actual conditions in road service and, therefore, felt justified in making tests under road conditions.

The G-6 brake valve was used throughout the tests.

Appendix I illustrates and describes the valve; Appendix II gives in detail the results of tests of the valve, made in accordance with the requirements of the M. C. B. code of tests.

Your committee is of the opinion that a new code of tests for trains of 75 or 100 cars should be compiled. It would also recommend that the testing rack at Purdue University be redesigned to allow of testing as many as 100 brakes of either 8-in. or 10-in. equipment.

AUTOMATIC CONNECTORS.

Committee—F. M. Whyte, chairman; C. E. Fuller, F. H. Clark, George W. Smith.

The notice sent out by the secretary to the members of this committee notifying them of the appointment of the committee and the membership of it outlined the duties as follows: "The committee to prepare standard dimensions for automatic couplings for steam heat, air brake and air signal, also to fix the relative locations and dimensions of the different parts, so that as cars are equipped from time to time with such automatic coupling the various makes will be interchangeable, one with another."

It is recommended that these devices be called connectors, instead of couplings; so that in writings and in conversations they may be distinguished the more readily from the drawbar device. This report will refer to them as automatic connectors.

Of the automatic connectors now in use there are two general types, the important difference, and the one which must be reconciled before the instructions to the committee can be carried out, is the line on which two engaging connectors are parted. In the one type the parting is on a line at right angles to the center line of track; these make a butt joint and may be referred to as butting connectors. The other type is parted on a line parallel with the center line of track; this may be referred to as the lapping connector. It would be impossible to couple one type directly to the other.

The lapping type is made by one company, and we have their opinion to the effect that their patents would prevent others from making a connector similarly parted. The butting connector is made by at least four firms, and the interchangeability of the four butting connectors can be readily accomplished. There are some of both types in service.

Your committee thinks that under the circumstances it is not warranted in recommending either type as standard, but because of the patent situation it favors the butting connector. If these views meet with the approval of the Association, it is recommended that the present committee be continued, or a new committee be appointed and requested to follow out, with respect to the butting connector, the instructions quoted in the first paragraph of this report.

The committee recommends further that the railroads discourage the use of automatic connectors until the manufacturers make arrangements by which any company may make a connector which will couple with the connector made by any other company.

SUBJECTS FOR COMMITTEE INVESTIGATION DURING THE YEAR 1906-1907.

Committee—James Macbeth, W. E. Fowler, O. M. Stimson, R. P. C. Sanderson, F. E. Davis.

First.—Up-to-date passenger car cleaning.

Second.—By introduction or use of the solid knuckle, would it not be advisable to increase the limit of variation in height of couplers from 3 to 4 inches, minimum height 31 inches, maximum 35 inches?

Third.—The present brake head should be made so as to allow the brake beam to hang horizontal as near as possible for either inside or outside hung brakes, at the M. C. B. standard heights of 13 inches for inside and 14½ inches for outside, and make a standard distance between the face of the M. C. B. standard brake shoe and the fulcrum hole of the beam for live and dead lever.

Fourth.—Passenger car ventilation.

Fifth.—Wheels for cars of 100,000 pounds capacity and the stresses to which they are subjected.

Sixth.—Best location and use of the conductor's brake valve.

MASTER MECHANICS' ASSOCIATION.

ABSTRACTS OF PAPERS AND REPORTS.

(*Continued from page* 288.)

WATER SOFTENING, FOR LOCOMOTIVE USE.

Committee—J. A. Carney, chairman; L. H. Turner, R. Quayle, C. E. Fuller, J. F. Dunn, J. G. Neuffer.

While your committee has expressed itself that the purification of water before delivery to the locomotive boiler is desirable, it also realizes that there may be conditions where the cost of erecting a purifying plant might not be advisable, and that some treatment of the water in the boiler is necessary. Whatever the treatment may be, a carefully systematized blowing-off process must be instituted without which no treatment of water in a locomotive boiler can be successful.

The committee gives below a series of reports of the results obtained by treating water, both before feeding it into a locomotive boiler and treating it in the boiler.

NO. I.—CONTINUOUS PROCESS.

The following is a brief report of the results obtained by a railroad purifying water by means of a continuous process. There are ten plants in operation and the following figures give the cost of treatment, together with the results obtained. In connection with the treatment of water is an elaborate system of blowing off and washing with hot water:

	Total gallons pumped.	Pumping cost per 1,000 gallons, labor, fuel, etc.	Treating cost per 1,000 gallons, labor, chemicals, etc.	Total per 1,000 gallons.
A*.....	128,900,000	4.00 cents	1.80 cents	5.80 cents
B.....	48,085,000	2.16 "	1.27 "	3.42 "
C.....	38,000,000	2.11 "	1.48 "	3.59 "
D.....	47,360,000	1.3 "	1.18 "	2.48 "
E.....	47,200,000	1.1 "	1.24 "	2.34 "
F.....	200,300,000	0.6 "	1.07 "	1.67 "
G.....	44,690,000	0.7 "	2.03 "	2.73 "
H.....	18,290,000	3.52 "	3.26 "	6.78 "
I.....	28,630,000	2.93 "	2.53 "	5.46 "
K*.....	22,700,000	7.00 "	4.02 "	11.02 "
Total.....	624,155,000			

Average cost of pumping, including cost of fuel, labor, etc. (No interest on investment and no allowance for deterioration) per 1,000 gallons.....2.037 cents.
Average cost of treatment, including labor, chemicals, etc. (No interest on investment and no allowance for deterioration) per 1,000 gallons.....1.589 cents.
Total average cost of water per 1,000 gallons pumped, treated and delivered to storage tanks.....3.626 cents.

*Water is purchased at 4 and 7 cents per 1,000 gallons, respectively.

Also please find statement showing the practical result as found from our reports of August, 1902, using untreated water, and November, 1905, when treated water was very generally used, relating to leaking engines and boilers washed.

TRAINS GIVEN UP.
August, 1902 27
November, 1905 .....None.

ENGINES SETTING OFF CARS ACCOUNT OF LEAKING.
August, 1902 13
November, 1905 .....None.

ENGINES CUT OFF THROUGH TRAINS ACCOUNT LEAKING.
August, 1902 45
November, 1905 5

ENGINES HAVING TUBES CAULKED.
August, 1902 803
November, 1905 469

BOILERS WASHED.
August, 1902 466
November, 1905 146

BOILERMAKERS' WAGES.
August, 1902 .....$401.50
November, 1905 ..... 210.90

BOILERWASHERS' WAGES.
August, 1902 .....$485.50
November, 1905 ..... 399.75

LIFE OF TUBES AUGUST, 1902.
20 by 26 inch cylinder consolidation, 11 to 12 months.
21 by 30 inch cylinder consolidation, 8 to 10 months.

LIFE OF TUBES NOVEMBER, 1905.
20 by 26 inch consolidation.....27½ months.
21 by 26 inch consolidation.....13½ months.

About 10 per cent. less engines handled in 1905 than in 1902; 20 by 26 inch engines in somewhat lighter service in 1905 than in 1902. Other engine service the same.

The water is treated for carbonate of lime, sulphate of lime and sulphuric acid by the use of lime and soda ash, applied through the continuous system. The treatment of water causes some boil-

ers to foam; this is taken care of by the water-changing devices which enable the complete discharge of the contents of a boiler containing 2,500 gallons and fill it and have the engine ready for service in thirty-two minutes without dumping the fire.

The report of comparative cost of boiler washing with and without treated water, includes the cost of water changing.

We are not able to show to what extent the life of the fire boxes has been increased, but boxes that were scheduled to be renewed one year ago are in service and doing well. The life of the tubes has been materially increased. The greatest benefit derived from water purification is the ability to keep locomotives in more constant service, with a great reduction of engine failures.

NO. II.—INTERMITTENT PROCESS.

The following is a report from a railroad using an intermittent process of water purification:

The water is mixed with chemicals and allowed to flow into a settling tank. After the sediment has settled the water is pumped into service tanks, two or three settling tanks being used at one plant. Through the use of purified water, 35 boilermakers at $10.40 per hour and 42 boilermaker helpers at $7.09 per hour in 1902, have been reduced in 1904 to 23 boilermakers, costing $7.71 per hour, and 35 boilermaker helpers, costing $6.70 per hour. This shows a decrease in the cost of boilermakers of 21.4 per cent. and a decrease in boilermakers' force of 56 per cent. The greater proportion of skilled help used in 1905 than in 1902 accounts for the discrepancy between the saving and cost and reduction of force. The tabulated statement gives the reduction in number of boiler failures through the use of purified water:

	August, 1902, to and including June, 1903.	August, 1903, to and including June, 1904.
Leaky flues	544	99
Leaky fireboxes	33	20
Leaky arch tubes	6	1
Total	583	120

There has been a reduction of 80 per cent. in boiler failures in 1903, over 1902 and the reduced number of failures was made with an increased tonnage. In 1902 there were 2,934,930,377 ton-miles handled with 28.7 pounds coal per 100 ton-miles; in

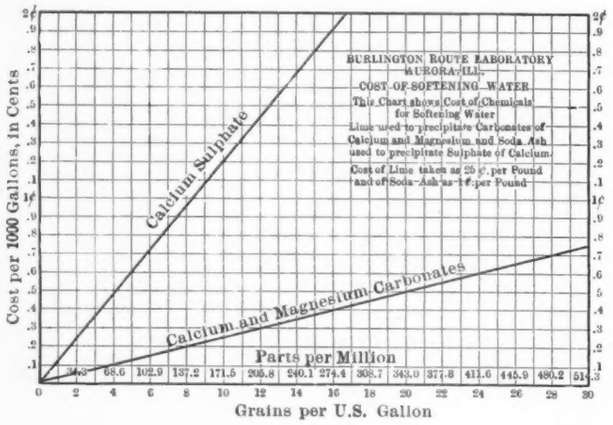

BURLINGTON ROUTE LABORATORY
AURORA, ILL.
COST OF SOFTENING WATER
This Chart shows Cost of Chemicals for Softening Water
Lime used to precipitate Carbonates of Calcium and Magnesium and Soda Ash used to precipitate Sulphate of Calcium.
Cost of Lime taken as 25 c. per Pound and of Soda-Ash as 1 c. per Pound
Calcium Sulphate
Calcium and Magnesium Carbonates
Parts per Million
34.3 68.6 102.9 137.2 171.5 205.8 240.1 274.4 308.7 343.0 377.3 411.6 445.9 480.2 514.3
Cost per 1000 Gallons, in Cents
Grains per U.S. Gallon

FIG. 1.

1903, 3,154,484,507 ton-miles were handled with 27.5 pounds per 100 ton-miles.

In 1902 159 engines were used and in 1903 154 engines were used with 6.6 per cent. increase in ton-miles, with a saving of 4 per cent. in the number of engines.

The above figures show that the boilermakers' force was reduced 56 per cent., the cost of boilermakers 21.4 per cent., engine failures decreased 80 per cent. and the tonnage increased 6.6 per cent., with a decrease of number of engines used of 4 per cent.

It is difficult to say to what extent the cost of labor and material for maintaining engines had been effected by purified water, but it is safe to say that a material decrease has been effected in this direction. Engines that formerly had their flues reset and heavy repairs to fire boxes, are now taken in for repairs to machinery and resetting a portion of the flues only, and from six to eight months' additional service is obtained.

The benefits to be derived and which can not be computed in dollars and cents, are the short time required for engines on the rond, due to tight boilers. the better feeling among the men and longer time at terminals, which not only gives time to keep the engines in better condition, but makes a greater saving in coal due to shorter hours on the road and less overtime paid to engine and train crews.

Engines which ordinarily would be held in for emergency relief calls, are now sent out in regular service, so that a better distribution of power can be made. These items are very difficult to reduce to dollars and cents value, but they mean an immense saving.

NO. III.—MECHANICAL PROCESS.

The following is a report from a railroad using a process for purifying water after it is fed into the boiler:

The device used consists of a system of perforated pipes and blow-off cocks. The water is purified by a special oil introduced into the boiler. The success of this device depends upon absolutely living up to the blowing-out instructions. The results obtained are as follows:

First—Decrease in the times locomotives have their boilers washed which amounts to	83	per cent.
Second—Increase in service of flues between resetting of	24.82	per cent.
Third—Increase in average mileage per engine between engine failures	147	per cent.
Fourth—Increase in mileage of engines between resetting and removing of flues of	7.35	per cent.

The fire boxes are kept comparatively free from scale, which reduces the amount of boiler work necessary and increases the life of fire box. This system of purification shows a decrease in the cost of operation of $1,523.03, or equal to 41.7 per cent. For less number of times boiler washing, has been calculated on $15 per day for engine and for the period of one month will amount to $2,025. The saving in wear and tear to machinery is estimated at $25 per engine per year, and amounts to $400. These figures added to the decrease of operation, $1,323.03, will make the total saving for one month of $3,748.03, or a saving for a period of one year of $44,976.36.

Below is detailed statement of above figures:

	Chemical Treatment.	Mechanical Treatment with Oil.
Number of times boilers washed	1,117	192
Cost of operating chemical plant	$454.29	.....
Cost of washing boilers	$2,721.51	$490.77
Cost oil used in oil treatment	.....	$1,362.00
	$3,175.80	$1,852.77
Decrease in cost	.....	1,323.03
Per cent. in decrease in cost	.....	41.7%

In addition to the above, the following estimated saving is effected:

Saving in time due to washing 925 additional times at 3 hours and 30 minutes each, equals 130 days at $15 per day for engine hire	$2,025.00
Saving to wear on machinery per month on the basis of $25 per engine per year, cylinder and valve work only	400.00
Total saving	$3,748.03
Percentage of saving	118 per cent.

Engines equipped with mechanical device, washed once a month.

Engines when using chemically treated, washed on an average of every five days.

NOTE.—As shown, the above performance is based on washing engine once a month, and while this can be done, conditions must be favorable. There are, however, times when conditions are such that require washing of engine twice monthly and in these cases we would arrive at the following figures:

	Chemical Treatment.	Mechanical Treatment.
Cost of operating chemical plant	$454.29	.....
Cost of washing boilers	2,721.51	$981.54
Cost of oil used in oil treatment	.....	1,362.90
	$3,175.80	$2,344.44
Decrease in cost	.....	831.36
Per cent. saving	.....	26%

NO. IV.—CONTINUOUS AND INTERMITTENT PROCESS.

This railroad is using a number of different devices for water purification. The continuous process and the intermittent process of treatment before the water is fed to the boiler and also treatment in the boiler.

On 206 miles of main line there are five water stations furnishing purified water, four of them being continuous process and one intermittent.

The flue failures causing a delay of more than five minutes on the divisions using this water have decreased as per following table, which includes freight and passenger:

Year.	No. Failures.
1901	805
1902	395
1903	332
1904	169
1905	135

NOTE.—No purified water in 1901, part purified in 1902-1903, and all water supply purified in 1904-1905.

During 1904, 1905, and for the four months in 1906, there have been no delays to passenger trains on the 206 miles using purified water, on account of leaky flues.

One division has been equipped for feeding from two to five grains per gallon to the suction pipe of the pump delivering the water to the supply tubes. The record of flue failures for thirteen months is as follows:

Year	1905	1905	1905	1905	1905	1905	1906
Month	Jan.	Feb.	Mar.	April	May	June	July
Failures	11	18	1	1	1	3	4
Year	1905	1905	1905	1905	1905	1905	1906
Month	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Failures	4	1	1	1	0	0	0

Engines using this treated water are equipped with a single perforated blow-off pipe in the back water leg of the fire box. It has been found that the mud works toward the back water leg and frequent systematic blowing off will keep the mud down to a minimum.

The following statement shows the saving made, due to treatment as above outlined:

FAILURES DUE TO LEAKY FLUES.

	No. Failures.	Total Mileage.	Miles per Failure.
Nov. and Dec., 1904, and Jan., 1905...	27	567,115	21,004
Nov. and Dec., 1905, and Jan., 1906...	1	605,196	605,196

	Staybolts replaced.	No. Men in Roundhouse.
Nov. and Dec., 1904, and Jan., 1905...	498	5 boilermkrs. 2 helpers
Nov. and Dec., 1905, and Jan., 1906...	103	2 boilermkrs. 2 helpers

	Boilers Washed. No. Times Washed.	Miles per Washing.
Nov. and Dec., 1904, and Jan., 1905...	389	1,432
Nov. and Dec., 1905, and Jan., 1906...	325	1,862
January, 1905.....	107	1,620
January, 1906.....	63	3,175

Engine 1718 ran from January 1, 1906, to February 8, 1906, as an experiment, and made 5,100 miles, and when opened up for washing, no more mud was found on the ring than in an engine which had made considerably less mileage.

Switch engine 1426, built new December 27, 1902, in constant service twenty-four hours per day, commenced to use the water treated by intermittent system in April, 1904; engine was given a general overhauling April 17, 1905, and no flues removed. It came into shop for a second overhauling February 10, 1906; flues were removed for inspection and it was found that they were barely coated with a fine powder which could be brushed off the iron. The switch engine was washed out every thirty days.

Consolidation engine No. 3164, in pusher service twenty-four hours per day, had flues reset September, 1904; the engine came in for general overhauling November, 1905, and the flues were removed. It was found there was practically no scale on any of the flues or accumulation of mud or scale in any part of the boiler. This engine had been using purified water exclusively and the flues were removed for inspection. Both this engine and the switch engine mentioned above were blown out twice a day.

The cost of treatment for chemicals is shown in diagram No. 1. Lime quoted at ¼ cent per pound, and soda ash at 1 cent per pound.

It is difficult to determine how much scale-forming matter should be contained in a water before purification is necessary. The most approved method of water treatment does not remove all of the scale-forming material and it would be useless to treat waters so low in incrustating solids that they approached the quantity which the purifying process failed to remove.

Waters containing over three grains of calcium sulphate or magnesium carbonate, whether there is other scale-forming material or not should be treated. The treatment will not remove all of the scale-forming matter, but will convert the sulphate into carbonate, which produces scale to a much less degree than does calcium sulphate. Water containing over six grains of total incrustating solids, a part of which is sulphate, should be treated.

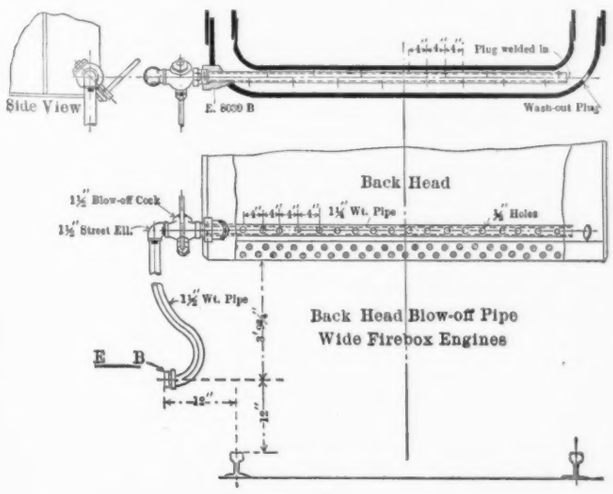


FIG. 2.

Water containing eight grains of incrustating solids, all of which are carbonate, should be treated. Any trace of free acid should be neutralized before the water is fed into the boiler.

There is no known method of treatment for alkali, and the only way to overcome its bad effects is to blow out the boiler systematically and thereby prevent the concentration of alkali, which will produce foaming. Systematic blowing off is necessary in any method of treatment and will do great good, even if no purifier is used.

An arrangement of perforated blow-off pipe placed at the bottom of the back water leg of a fire box is shown on diagram No. 2. This arrangement has been used on the C. B. & Q. R. R. for some time and has given most excellent results, keeping the boiler as free from mud as a much more complicated system of blow-off cocks would accomplish. A floating outlet pipe in the supply tank will be found of great benefit with muddy water, whether purified or not.

Your committee is indebted to Mr. C. M. Davidson, Chemist and Engineer of Tests of C. & N. W. Ry., and Mr. M. H. Wickhorst, Engineer of Tests, C. B. & Q. R. R., for information, method of treatment and results.

SPECIFICATIONS FOR CAST-IRON TO BE USED IN CYLINDERS, CYLINDER BUSHINGS, CYLINDER HEADS, STEAM CHESTS, VALVE BUSHINGS AND PACKING RINGS.

Committee—G. R. Henderson, chairman; E. D. Nelson, Max H. Wickhorst.

It is recommended that all purchases of pig iron be made by analysis. This necessarily implies penalties for non-conformity with specifications, and the amount of silicon is considered to be of prime importance as indicating the grade. High silicon irons—that is, low foundry numbers—are generally dearer than low silicon (high numbered) irons, and if the shipment does not contain the desired percentage of silicon, payment is made accordingly. Sulphur is the element to be most carefully kept down to the limit, and an excess of this substance will generally entail rejection under any grade.

When purchasing cylinders, valves, etc., analyses and test bars should be insisted upon, to demonstrate that the metal is in accordance with the desired specifications.

A locomotive cylinder should combine strength and hardness—the former to prevent breakage, the latter to retard wear; however, it must not be brittle and must admit of machining. A cylinder may be made of tough iron and a hard bushing inserted to give the wearing qualities. In fact we know of recent cases in which the cylinder shell has been a steel casting, with cast iron bushings inserted in the piston and valve chambers. Shrinkage must also be considered, as when excessive there are apt to be cooling cracks present in the casting.

When the silicon is above 1.80 per cent., excessive wear may be expected, but when below 1.00 per cent. there is liability to crack in cooling or in service.

Your committee recommends the following specifications for metal in locomotive cylinders:

Silicon	1.25-1.50 per cent.
Phosphorus	.50- .80 per cent.
Sulphur	.06- .10 per cent.
Manganese	.30- .60 per cent.
Combined Carbon	.50- .70 per cent.
Graphite Carbon	2.75-3.25 per cent.

Tensile strength, 25,000 lbs. per sq. inch min.

Transverse strength 3,000 lbs. minimum on 1¼-inch round bar, 12 inches between supports.

Deflection, .10 inch minimum on transverse test.

Shrinkage, ⅛ inch in 1 foot as a maximum.

TESTING.

The American Society for Testing Materials gives the following details for testing such castings, and your committee recommends them to the Association:

"The quality of the iron going into castings under specification shall be determined by means of the 'arbitration bar.' This is a bar 1¼ inches in diameter and 15 inches long. It shall be prepared as stated further on and tested transversely. The tensile test is not recommended, but in case it is called for it may be made from any of the broken pieces of the transverse test. The expense of the tensile test shall fall on the purchaser.

"(The tensile test piece should be prepared with threaded ends, 1¼ inches in diameter, and with a central neck 0.8 inch diameter, 1 inch between shoulders, with a 7-32 inch radius at the shoulders, the shoulders being 1 inch in diameter and ¼ inch in length to the thread, the total length of piece being about 3½ inches.)

"Two sets of two bars shall be cast from each heat, one set from the first and the other set from the last iron going into the castings. Where the heat exceeds twenty tons an additional set of two bars shall be cast for each twenty tons or fraction thereof above this amount. In case of a change of mixture during the heat one set of two bars shall also be cast for every mixture other than the regular one. Each set of bars is to go in a single mold. The bars shall not be rumbled or otherwise treated, being simply brushed off before testing.

"The transverse test shall be made on all the bars cast with supports 12 inches apart,, load applied at the middle, and deflection at rupture noted. One bar of every two of each set must fulfil the requirements to permit acceptance of the castings represented.

"The bars shall be molded two in a flask and cast on end; the bottom of the bar being 1-16 inch smaller in diameter than the top to allow for draft. Pattern shall not be rapped before withdrawing. The flask is to be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve with a mixture of 1 to 12 bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried and not cast until it is cold. The test bar shall not be removed from the mold until cold enough to be handled.

"The rate of application of the load shall be from 20 to 40 seconds for a deflection of 0.10 inch.

"Borings from the broken pieces of the arbitration bar shall be used for the chemical determinations. One determination for each mold made shall be required."

While the metal advocated is perfectly suitable for cylinder bushings, as well as cylinders (and we also think for valve bushings), a softer grade of iron is generally used for cylinder heads, steam chests, valve bushings and packing rings. This iron has a silicon content of from 1.60 to 1.80 per cent.; the other

elements remaining about the same. As shown on page 215, Vol. 30 of the Proceedings of this Association, the greatest strength was obtained with silicon at 1.60 per cent., and for cylinder heads and steam chests strength is most important. In packing rings a softer iron is desired to save the cylinder bore, and the strength is also a very important factor to prevent breakage when springing over pistons or from water accumulating in the cylinder.

Flexible Stay Bolts.

Committee.—R. N. Durborow, chairman; F. M. Whyte, C. E. Fuller, O. H. Reynolds.

The original flexible stay bolt, as far as can be determined from research by your committee, appeared about 1878, and was the invention of Herr Wehrenfennig, then Chief Engineer of Material and Traction of the North Eastern Railway of Austria, who also, it is claimed, was the first to draw attention to the need of a flexible connection between the two sheets of the boiler. This bolt in general design is similar to practically all that have followed, having a bolt proper with an enlarged head for applying and provided with a seat bearing against another seat provided for in a sleeve screwing into the outer sheet. The fire-box end was either fastened by riveting over or by screwing into a cap, but the main difference between this design and later ones is in the form of the seat which, in the Wehrenfennig, was flat, while all others have employed the ball and socket form.

No record of the service given by these bolts can be found, but about four years later an improved form of this bolt was devised and put in service by Mr. W. Leech, Foreman Boiler Maker of the Rajputana-Malwa Railway of India, who, in describing his bolt, stated that a large number were put in service in engines running in bad water districts, and that the bolts gave unqualified success, lessening stay-bolt renewals and prolonging the life of the boiler sheets.

Both the Wehrenfennig and Leech bolts were applied by first tapping the inner and outer sheets so that both holes were in alignment, next applying the sleeves and lastly the bolt itself by means of the square head extending from the head of the bolt, against which a sledge or "dolly" was held while the fire-box end of the bolt was being riveted over, the head remaining as an integral part of the bolt in the Wehrenfennig design, but is removed from the other form after it has served its usefulness in applying the bolt.

Your committee has no data as to how great an extent these early forms of flexible stay bolts were used but it is known that Leech never profited by his invention, from which it would appear that this was one of the useful inventions whose merit was not fully recognized during the life of the patent. This brings the subject to practically the present day, and to determine the experience of members of the Association with bolts of this general form, your committee issued a letter of inquiry to which fifty-eight replies were received. This may be considered as a satisfactory result, even though this does not represent a large percentage of the members of the Association as being interested in the subject. Thirty-two of the fifty-eight replies received were from roads not using flexible stay bolts, but in the twenty-six answers from roads using them, a number of the most prominent roads were included.

Five hundred and twenty-one thousand, four hundred and thirty-five (521,435) flexible stay bolts, of seven different varieties, distributed in 3,012 boilers, have been put in service among the twenty-six roads using such bolts. Of these seven forms, those shown in Figs. 4 and 5 have been the most largely used. The design shown by Fig. 4, which is the earlier one, developed several serious defects traceable to the screw slot by which the bolts are screwed into the sheet. These failures were usually from the bottom of the screw slot through or into the neck, and in some cases in the neck itself. In the former, the head doubled on itself, closing the screw slot, giving very insufficient bearing on the spherical surface. Stopping the slot short of the edge to prevent this buckling did not prove to be a satisfactory solution; hence this form, shown in Fig. 4, has been largely superseded by that shown in Fig. 5, though the service with it cannot be said to have extended over a sufficient period to justify a decision as to its merits. The bolt employs the ball and socket head, but does not use the conical walls for the sleeve for breaking up scale deposited, and aside from the fault indicated previously, Fig. 4, has given satisfactory service, some roads replying that they have experienced no failures, but all roads that have adopted it as standard report otherwise, showing the advantage of wide experience.

In point of favor, indicated by the number in use, Fig 6, (not reproduced) follows the preceding forms, and, regarding the design, appears to be the most satisfactory, as only one road reports a failure, this failure being caused by faulty manufacture in punching the hole for the wrench too deeply. The ordinary ball and socket joint, having a bearing between the bolt and the sleeve, is used, the walls of the bore of the sleeve being conical and very short, and your committee believes that this latter feature is an improvement on the designs shown by Figs. 4 and 5, inasmuch as the space for the lodgment of scale is lessened.

Fig. 7 shows the latest design, and though of comparatively recent date has been received with great favor, indicating the rapidity with which a new bolt of promising design is given a practical trial in the effort to cure the stay bolt trouble. Its actual service, however, has been of such short duration that nothing can be said in its favor or otherwise. The principles of this design were used in an older form and include the spherical headed bolt and recess with conical walls in the sleeve, but better designed for manufacture and for application.

It has been demonstrated that in certain locations the rigid stay bolt will not give reliable service in the large boilers carrying heavy steam pressure, and though very frequent examination will detect such failures before they become too numerous, nevertheless there is every indication that at certain locations some form of bolt that will allow of distortion without rupture is a necessity.

For solid bolts, some advocate a special grade of material, this being either a higher grade iron made up in the usual way, or iron made up in some special way. Your committee believes that, while good material is by all means desirable, it is firmly convinced that this alone will not overcome the troubles that have been experienced.

Besides changing the material, various modifications in the form have been tried and adopted, the general idea being to so

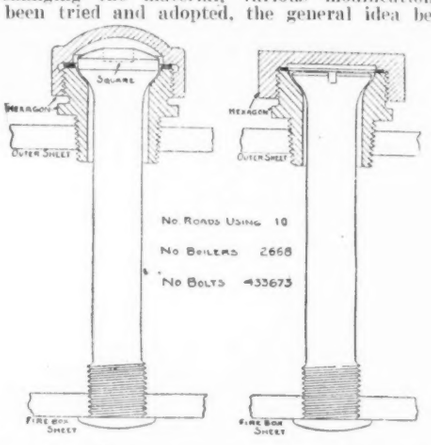


FIG. 5. FIG. 4.

shape the bolt that the vibration strains will not all locate themselves at one point, namely, the inside of the outer sheet. One of these special forms employs a bolt which is materially enlarged at the outer sheet, diminishing in diameter until the fire sheet is reached, the governing idea being that, by so shaping the bolt, the deflection will be distributed over its entire length. Experience shows that this result largely follows and that final fracture, when it occurs, may be at some distance from the sheet, but the disadvantage of tapping holes of different sizes in the two sheets, to say nothing of the greater expense of forming such bolt, renders its adoption very doubtful. The custom of reducing the diameter of the bolt between the two sheets, your committee believes to be a good one, provided the reduction is not made by an abrupt shoulder. Vibrating tests on the testing machine indicate that this reduction very greatly increases the capacity of the bolt to resist distortion, but it is the opinion of your committee that the reduction should not be carried too far, as it has been found in practice that with the size of bolts customarily used, a body 3-16 inch less in diameter than that of the ends will give better results than a greater or lesser amount of reduction. Other forms of solid bolts have been used in fittings designed to practically increase the length of the bolt. Various modifications have also been made with the idea of giving the rigid bolt greater flexibility. One of these is a bolt which is flattened locally in planes at right angles to one another, but the results obtained were not satisfactory.

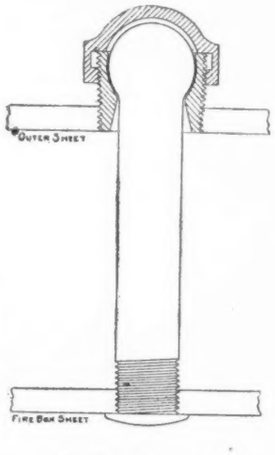


FIG. 7.

Other modifications, such as the milling of longitudinal saw-cuts in the body of the bolt, and of manufacturing the bolts in hollow form, have also been tried; the latter claiming to possess the additional advantage of better combustion and absolute indication of failure. Your committee is not prepared to admit that either of these claims have been proven.

All of these schemes have given more or less satisfaction, but none have fulfilled requirements to an extent that would warrant universal use.

Regarding the opinions of the users of flexible bolts as to the value resulting from a change from the rigid to the flexible form, the verdict is greatly in favor of the change, fifty per cent. of the replies received being in the affirmative and including the largest users; the remainder, excepting one, answering in a manner that could not be interpreted as either for or against their value.

Concerning the location of flexible bolts there appear to be four places applicable to all boilers that have proved to be a source of trouble to rigid bolts, and where the application of flexible bolts has stopped entirely, or to a great extent, the failures of the older form, these places being the two upper corners of the throat and side sheets. Beyond this the application is increased as the individual judgment indicates.

Naturally the results obtained from flexible bolts vary to an extent, depending upon the conditions, these conditions including such items as design of the bolt, application of the bolt, design of the boiler, and incrustation, these four factors being the most important affecting its life. In the bolt itself it is admitted that,

strictly speaking, it is not a flexible bolt, for though it is made in two parts it still has to withstand bending strains, due to the manner of expansion in the sheets, the bending taking place at some point near the inner sheet. This action be overcome by employing a flat bearing surface at right angles to the head of the bolt instead of the ball and socket joint as commonly used. As better contact is maintained between the head and sleeve in actual service with the ordinary form, and further, as trouble has seldom been known to result from the bending strains due to the expansion of the sheets, which would be indicated by bolts breaking at some point near the inner sheet, or by leaking at the fire-box end (a trouble that is seldom, if ever, encountered), it is evident that this is a trifling fault, but one that should be borne in mind while considering the designing of new bolts. The finding of the point of failure of stay bolts at the outer sheet, and that the failure seldom, if ever, takes place at the inner sheet, is possibly due to the high temperature of the fire box making the inner sheets more elastic. This allows them to bend to an extent, relieving the stay bolt to some degree of the strains imposed upon it at this point. It should also be remembered that in most designs the outer sheet is materially thicker than the inner or fire-box sheet.

A simple means of positively detecting cracked and broken bolts is an improvement needed by all flexible bolts that are in service at the present time. The removal of the cap, which will allow a proper examination of the bolt, is the only absolute means possible with flexible bolts of present design. On account of corrosion, it is not an easy method and often results in destruction of the cap. The inspection of flexible bolts located in side sheets and back head can only be made by the removal of lagging. The designing of the flexible bolt, so that the telltale hole may be employed, by filling the space between the head of the bolt and the cap with a packing material, may or may not be a good feature for determining cracked and broken bolts. As the use of the telltale hole is a disputed practice, its action not being accepted as positive, and as it adds to the expense of application and maintenance, it is not to be recommended for this purpose.

The first consideration in the application of bolts should be the securing of proper alignment of the holes in the inner and outer sheets, in order that the clearance between the bolt shank and the sleeve may not be decreased, leaving a larger amount on one side than on the other, and so reducing its value as a flexible bolt when expansion of the sheets takes place, as this will give the possibility of an added strain upon the bolt due to the bolt shank acting as a lever arm with the sleeve as a fulcrum. Also if the bolt and sleeve do not contain the same perpendicular for a center line an indirect strain comes upon both members. These two conditions, which may occur in conjunction, giving complex strains to the bolt and sleeve, will undoubtedly affect the life of the bolt to some extent; but even if each occurs separately, the already severe service of this member of the boiler is unnecessarily added to, reducing its life to an extent commensurable with the increased demands. The cure for these faults is simple, only needing care in the final reaming and tapping of each pair of holes. Unfortunately, however, none of the methods employed in the application of flexible stay bolts were described by the members in their reply to the circular.

There also exists the possibility that in applying the bolts, different ones may be given varying initial strains, those receiving the greatest naturally suffering the hardest service, and it is easily seen that with a great enough difference in initial strain between one bolt and those surrounding it, rupture may be an easy matter.

The effect of the design of the boiler upon the life of the bolt can be seen from the accompanying diagrams, Figs. 29 to 45 (not reproduced) inclusive, which give the records of broken stay bolts. These figures show the failure of both flexible and rigid bolts, and the tabulations on these sheets show the method of indicating such failure and, also, give other information from which it can be said that each class of boiler has its own local weakness at which failure occurs most frequently; but in general it may be said that the point at which there is a bend in the sheet is one where failure may be expeected. In some of the later designs, particularly those of wide fire boxes, the greatest number of failures occur at the first few rows above the mud ring.

Incrustation has been the principal difficulty that flexible bolts have had to contend with and this trouble has been the cause assigned for most failures, there being but little doubt that this is true, for the deposit of solid matter around the bolt and its parts will defeat the purpose of the flexible bolt, making it of little more value than the rigid; and, though the fault may be a local one, affecting only such engines as run in districts supplied with scale-forming water, any design of flexible bolt which will admit of this taking place is in general a weak design.

It may be said that all bolts of to-day possess this fault, though some, in a manner, have obviated the difficulty. A fault common to all lies in the sleeve, which should not be made too large on account of weakening the outer sheet, nor should the bolt be decreased for reasons of strength, the result of either being an increase of clearance around the bolt. The proper procedure is the omission of that portion of the sleeve below the seat of the bolt, thus preventing the possibility of the scale being deposited between the bolt and sleeve, preventing free movement of the bolt with the movement of the sheets. Some designs have made use of a conical wall in the sleeve to aid in keeping the scale from collecting, but it has been found from experience that this feature, aided by the movement of the sheets and continual jarring of the engine, does not serve its purpose under all conditions. Sucfi scale that is deposited is formed grain by grain, and may result in a hard, homogeneous mass which will take a heavy blow to break up, yet the only action that takes place between the bolt and sleeve is of a grinding nature, which at the most will keep but a small space around the bolt clear, and any movement beyond the average demanded of the bolt will not be met.

In such varieties of bolts that use the flat head, incrustation will surely produce a solid bolt if conditions are favorable, the time depending on the amount of clearance between the bolt head and cap, for water and steam get past the seat of the bolt and sleeve, depositing such salts as may be contained. With the spherical-headed bolts this cause of rigidity may be overcome or lessened, for, theoretically, all the clearance required by this form is anything less than actual contract and, practically, enough to provide for irregularities due to manufacture. It is safe to assume that this amount of clearance will always be present, due to vibration and movement of the bolts.

There has been a small amount of trouble that neither of the above forms provide for, namely, if scale is deposited above the head of the bolt, no provision is made for taking care of expansion of the bolt and approaching of the sheets, which has been known to result, with sleeves using brass caps, in the forcing out of the center of the cap. It is evident that the amount of trouble resulting from incrustation depends entirely upon the amount of solid matter contained in the water and whether it deposits as a hard or soft scale.

The fact that there is a movement of the firebox and outer sheets has always been recognized, but what this movement amounts to and the direction it takes appears to have been known only in a vague and indefinite way, an investigation of a thorough character having apparently, from a careful research by your committee, never been conducted. Considering the different sheets that form the firebox of the boiler as plane surfaces, expansion of these sheets takes place in two different planes, one in a plane containing the sheets that may be under consideration, and the second is a plane perpendicular to these sheets, it being a separation or approaching of the inner and outer sheets of the boiler. In an investigation the individual expansion of each sheet is of no definite value, for if both the inner and outer sheets move the same amount in the same direction, no change of position of the stay bolt would take place, but if the expansion of each sheet occurred in opposite directions the movement of the bolt would be greatest. From this it is seen that all that concerns the bolt is the relative movement of the inner sheet with respect to the outer.

The expansion of the two sheets in their own plane, which, for convenience, may be called horizontal, is due to the changes of temperature, but the expansion in the other direction, which may be called the vertical expansion, is due to a combination of forces, among which are the expansion of the stay bolts, the buckling tendency due to the expansion of the sheets in a horizontal plane being confined to a certain extent by the stay bolts and other fastenings, and the separating force exerted by the steam pressure.

In order to obtain definite information that would give the amount and direction of these movements, your committee conducted such experiments that would give this information, and though all data desired were not obtained, yet definite results were accomplished. Starting with the idea of determining only the relative movement of the two sheets, an apparatus was devised, consisting of a casing, containing parts making steam-tight joints, screwed in the outer sheet and a plug screwed in the inner sheet. Driven on this plug was a length of seamless steel tubing at the free end of which was attached a brass cap, the brass cap being free to slide against a half-round ring, provided to guard against the non-alignment of holes in inner or outer sheets, and so as either sheet moved in the horizontal plane a steam joint was always kept. Resting on the half-round ring and kept in contact with it by means of a spring under proper compression, was a ground piston capable of being moved up or down, obtaining by this means a steam joint if any movement in this direction took place. These three joints thus provided for any movement whatever that might take place. To provide for the relative movement of the sheets, the table for holding the papers on which the records were made was attached to the casing held by the outer sheet, and the recording levers were connected to the plug, fastened in the inner sheet by means of a rod entirely free of all restraining pressures. For the movement of the sheets in a horizontal plane, a pantagraph of usual construction with a ratio at the pencil of approximately eight times the movement at the moving point, and for the vertical movement a simple lever also with a ratio of approximately eight to one, were used.

In addition to the information given by this apparatus the temperatures of the firebox and the outer sheet should be known and an attempt was made to obtain this data, but, due to the difficulties encountered, the attempt resulted in failure.

In conducting the trials two passenger engines, one of the Belpaire and the other of radial stay construction of modern type, which had just passed through the shops for repairs, were selected, and the points of greatest stay bolt failures obtained from the record sheets of these types of engines. Three or four points depending upon the construction of the boiler were selected from each of the four sets of sheets comprising the firebox. After the necessary work had been done on each boiler—which included one injector in proper working order, the throttle valve in good condition, the valves, piston and cylinder heads removed to allow free passage of steam when the throttle was opened, and a measuring device placed in each hole of one of the four sets of sheets—the preliminary data were observed and the fire started in the boiler, steam being raised as quickly as conditions would allow. The method of urging the fire was that found in ordinary engine-house practice and consisted of a steam blower supplied from the engine-house piping, which was used until the boiler pressure was high enough to supply steam for the blower.

Readings were taken at frequent intervals until a steam pressure of 25 pounds per square inch was reached, after which they were taken at intervals of 30 pounds until the normal pressure was obtained, at which point the pressure was allowed to remain stationary for ten minutes, so that the different parts of the fire box might obtain the proper temperature and thus be in a state of rest. At the end of this period the throttle was opened

for ten or twenty minutes, blowing off approximately two gauges of water, keeping steam as near the working pressure as possible. This does not give the intermittent action of using steam in actual practice which may affect stay bolts to some extent, but represents, as near as could be obtained, service conditions. After readings had been indicated on the records, the injector was applied to restore the water used while the throttle was open, not attempting to keep the steam pressure up, as in this way the greatest reduction in temperature of the sheets could be obtained. When the usual readings had been recorded and steam pressure had been restored, the firedoor was opened for five minutes to obtain a maximum condition to represent the opening and closing of the door while on the road, and which would show distinctly on the record sheet any movement due to this cause. After this period the fire was withdrawn from the firebox and the throttle opened, allowing about fifteen minutes for reducing the pressure to zero, and at this point the blow-off cock was opened, the water allowed to drain, and the boiler, with all devices in place with fresh record cards, left to cool, thus obtaining the action taking place during cooling as well as heating.

[Drawings of the apparatus used and tables showing the results of the tests were included in the report.]

The greatest movement, as might be expected, occurred at the crown sheet and upper corners of the side sheet, but very little took place at the top of the back head where some amount might be looked for, even though this is the firebox sheet of lowest temperature. Practically no movement whatever was shown at the lower corner of the side sheets. This may be explained by the lower temperature, the points measured being in the bed of the fire. The restraining effects of the heavy mud ring and its fastenings probably also contributes to this result.

The greatest movement obtained in a horizontal plane was at point "F" (center of front edge), on the radial stay crown sheet, where the difference in movement of the two sheets amounted to .08 inch and .09 inch—about 3-32 inch—with rising and falling temperature respectively, and to .06 inch in the vertical plane at point "B" (near center of back edge), on radial stay crown sheet with falling temperature. From this it appears that the relative movement is very small, and, from a further examination of the table in but few instances did the difference in movement of the two sheets greatly exceed .015 inch (1-64 inch).

There is very little difference in movement between the radial stay and Belpaire types of boilers. Some claim that a movement of the sheets takes place as the steam pressure varies or when the firedoor is opened during the operation of firing, but referring to the cards, no signs of such movement can be detected. This movement was particularly looked for as the tests progressed, but as no indications were observed, and as conditions were aimed to give results much more severe than would be derived in practical work, it must be assumed that any such movement is infinitesimal in amount. In some of the diagrams a reversal of direction is shown to have taken place and this means the bolt has undergone a reversal of strain which, in the horizontal plane, indicates a bending action taking place. However, little of this reversing took place after the boiler was under normal pressure for ten minutes. Nevertheless it is interesting to know that the line of fracture of broken stay bolts closely agrees with the general direction taken by the sheets in expanding as indicated by the diagram, and that failure is probably due to a repetition of small movements over a long period and aided by the tension exerted by the separation of the sheets.

In conclusion, your committee believes that flexible stay bolts are giving very satisfactory service where the design is good and the conditions are favorable. The only unfavorable conditions which seriously affect the service are bad workmanship and water containing hard scale-forming material; the first condition being less serious than the second.

It has been shown that there is a definite movement of the sheets, of small amount, from the cold boiler to the working pressure temperature and that the movement has an effect upon the life of the bolt. Any small changes of temperature, caused by the operation of the injector, reduced steam pressure, or the opening of the fire door, produce a movement of the smallest amount.

Your committee believes that it is wise to substitute flexible bolts at the points where experience shows the greatest breakage of rigid ones, and that no hard and fast rule can be laid down to show where this occurs, as this location is affected by the design of the boiler; that the flexible bolt must be one designed to minimize the difficulty from incrustation; that it must be of proper strength and with sufficient clearance in its fittings; and finally, that the design should, if possible, be one to facilitate examination. With these conditions observed, your committee is convinced that the flexible bolts will give great relief from the present troubles.

Tire Shrinkage and Design of Wheel Centers.

Committee—F. J. Cole, chairman; J. E. Muhlfeld, A. S. Vogt, W. A. Nettleton.

General.—The dimensions, design and weight of wheel centers should, in a general way, be of suitable proportions to the weight and power of the locomotive. These recommendations, therefore, will be found somewhat too heavy for locomotives of moderate weight, and will be understood as applying to large, heavy, modern engines of proportions such as are used at the present time.

SPOKES.

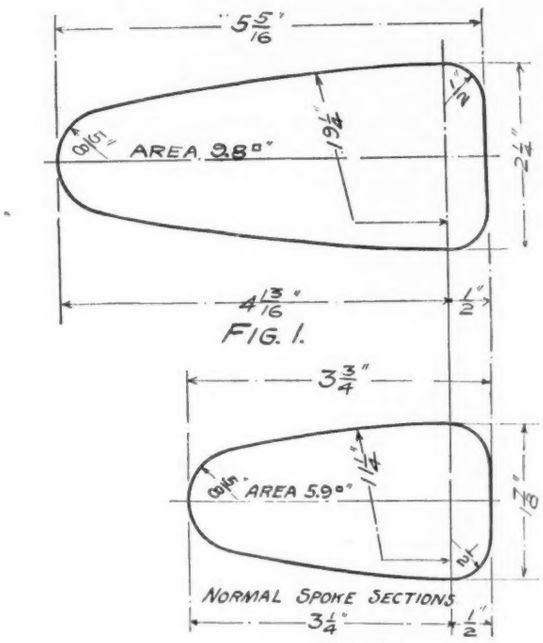
In order to properly support the rim and to resist the tire shrinkage, the spokes should be placed from 12 to 13 inches apart from center to center, measured on the outer circumference of the wheel center. Your committee would recommend the following approximate rule:

Number of spokes to equal the diameter of center divided by 4. If the remainder is one-half or over, use one additional spoke. The exact spacing of the spokes according to this rule would be $3.1416 \times 4 = 12.56$.

Wheel centers arranged in this manner would have the following number of spokes:

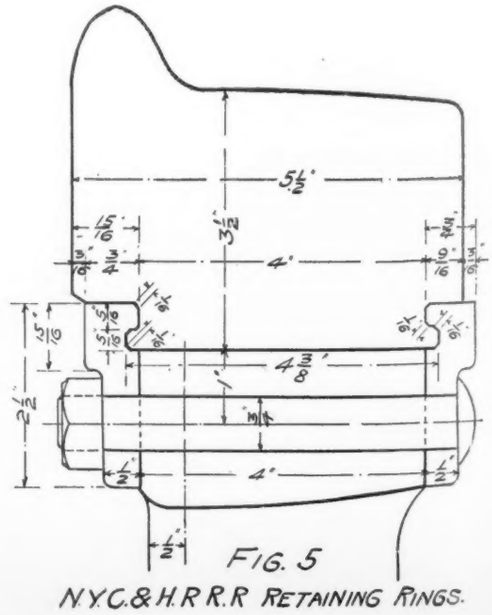
Size of Center.	No. of Spokes.	Size of Center.	No. of Spokes.
38	10	72	18
44	11	74	19
50	13	76	19
56	14	78	19
62	16	80	20
66	17		

Among patternmakers and foundrymen there is an impression



that an uneven number of spokes should be used, so as to avoid getting two spokes directly opposite each other in a straight line. The following table has been made up on this basis:

Diam.	Circumference.	Spokes.	Recommended Pitch.
44	138.23	11	12.5
48	150.8	11	13.6
50	157	13	12.6
54	169.65	13	13
56	176	13	13.5
60	188.5	15	12.6
62	194.8	15	13
66	207.3	15	13.8
68	213.6	17	12.5
70	220	17	12.9
72	226.2	17	13.3
74	232.5	17	13.6
76	238.76	19	12.6
78	245	19	12.9



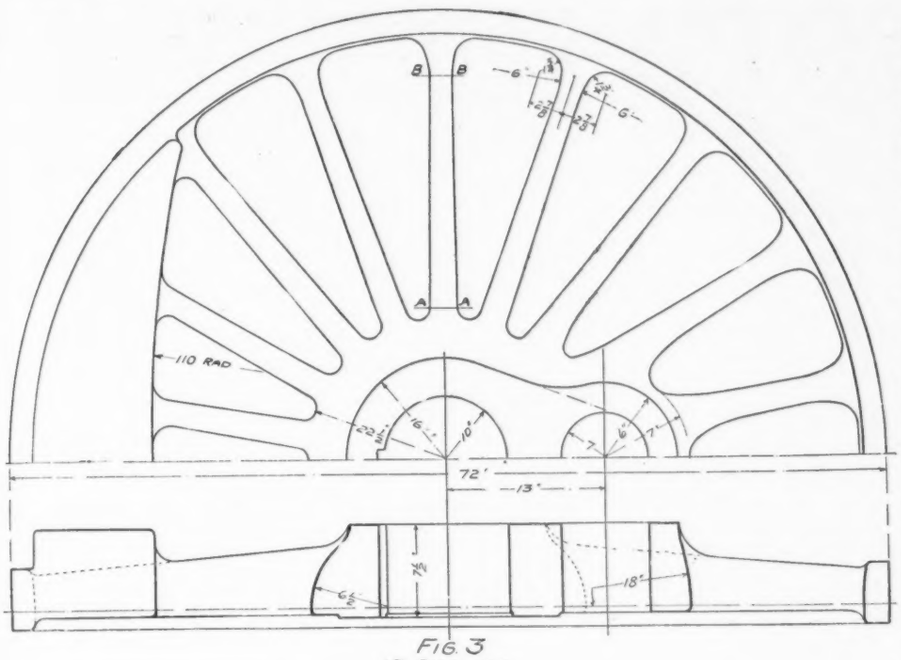


FIG. 3
18 SPOKES

In the above table, the pitch of spokes, measured on the outside of rim, is 12.5 to 13.8.

Spokes at crank hub should not be located at center line of wheel, but on either side, so as not to bring a short spoke directly in line with crank pin hub. Sections of spoke to be from 9 to 10 square inches in area, with form as shown in Fig. 1, for the big end. Section at small end to have an area of from 5¾ to 6 sq.-ins., with form as shown in Fig. 2. These sections are taken at the base of the fillets uniting the spoke to the hub and rims, as shown in Fig. 3 at AA and BB. The metal in these sections is distributed so as to give the maximum amount of resistance to the shrinkage of the tires, and with this end in view the section is much heavier directly underneath the part of the tread which bears directly upon the rail head.

RIMS.

Cast-steel driving wheel centers should be preferably cast with the rims uncut and shrinkage slots omitted whenever steel foundries will guarantee satisfactory castings. The P. R. R. Co. have been obtaining wheel centers with uncut rims for the last two years or more. A number of cast steel foundries are now ready to make wheel centers in this manner.

For wheel centers 60 inches and over, where the permissible total weight of the engine will permit, the rims should preferably be cast solid without cores, so as to obtain the maximum section and have full bearing of tires. The section in square inches should be approximately .45 of the sectional area of the tires when new; for instance, a 5½ by 3½ inch flanged tire has a sectional area of 20.2 square inches. This would require a rim with 9 square inches of metal. A 3 by 5½ inch flanged tire has a sectional area of 17.5 square inches, requiring a rim of approximately 7.9 square inches. In our opinion, it is not necessary to consider the increased area of flat tires.

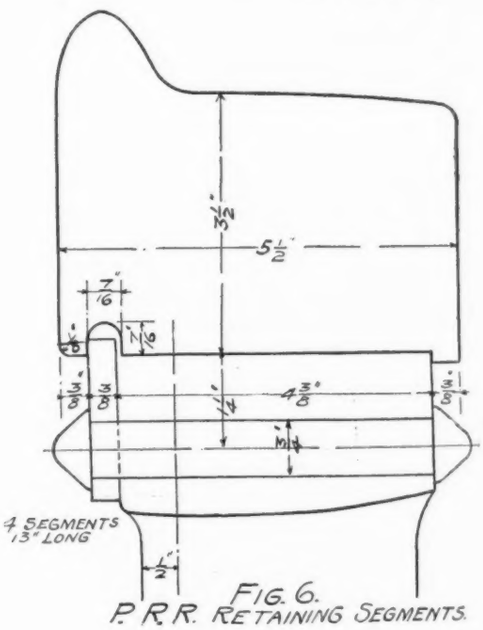


FIG. 6.
P. R. R. RETAINING SEGMENTS.

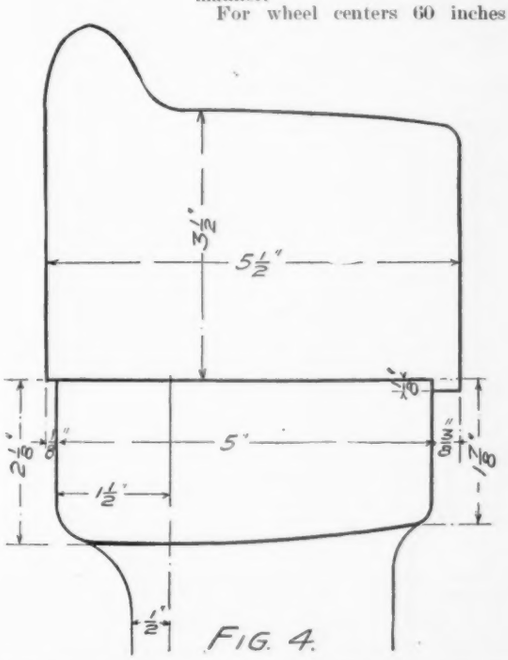


FIG. 4.

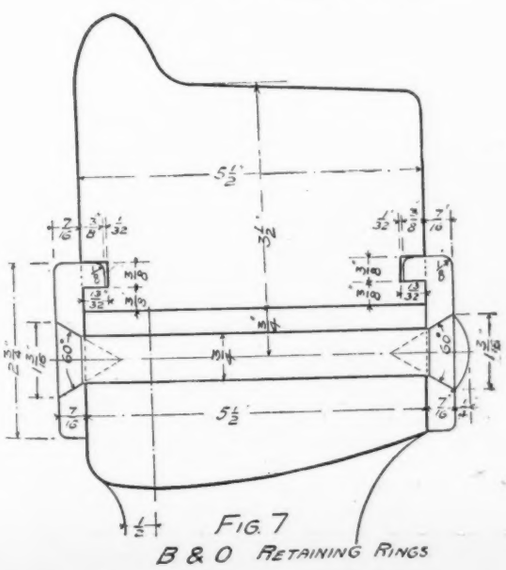


FIG. 7
B & O RETAINING RINGS

It is difficult to get sufficient counterbalance in centers smaller than 60 inches in diameter, so that it will be found very desirable to core out the rims to obtain the maximum lightness on the side next to the crank pin, and in some cases on the counterbalance side, in order to fill in with lead where necessary. Your committee would recommend a rim section as shown in Fig. 4, for wheel centers without retaining rings. The tire is secured from having the center forced through it by a lip on the outside ⅜ inch wide and about ⅛ inch high, the tire being left rough at this point. The exact height of the lip therefore depends upon the amount of finish left on the interior of the tire.

RETAINING RINGS.

There is so much diversity of practice in the use of retaining rings that your committee does not feel justified in recommending any particular form.

The standard form used by the New York Central Lines, rim 4 inches wide, is shown in Fig. 5.

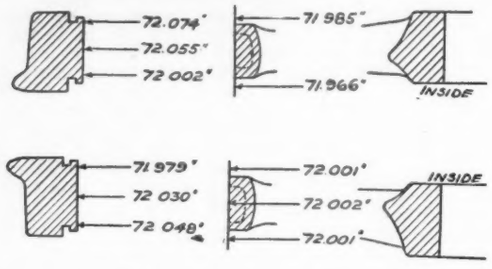
The standard form of Pennsylvania retaining segments is

shown in Fig. 6. The tire is secured by means of retaining segments and a lip on the outside of the tire. The lip is ⅜ inch wide and about ⅛ inch high, and is equal in depth to the amount left by boring out the tires. The four retaining segments are ⅜ inch thick and about 13 inches long, secured by two rivets through each segment, located at junction of spoke to rim.

The standard form of B. & O. Mansell retaining rings is shown in Fig. 7, with a rim 5½ inches wide.

SHRINKAGE SLOTS.

It is becoming more and more the practice of steel foundries



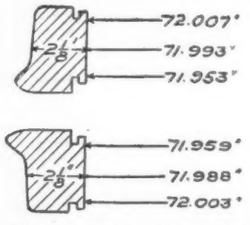
to cast rims without shrinkage slots and several of them are now prepared to guarantee satisfactory results. We would recommend the adoption of this practice whenever foundry methods will permit, as the rim of the wheel is stronger and better adapted to resist the strains to which it is subjected when the rim is left uncut. The extent to which this practice may be used depends entirely upon the attitude of steel manufacturers. It is well known that the shrinkage strains can be taken care of and that cast steel wheel centers of all diameters required for locomotives have been made successfully in this manner for several years.

HUBS.

In order to prevent an excessive dish to the spokes we would recommend that a standard distance of 55 inches between hubs be adopted. This permits the use of a practically straight spoke without dish on the inside.

In boring out the tires and in turning off wheel centers, a wide-nosed tool should be used and care taken that the surface of the finishing cut is not left in ridges. It has been observed that when ridges are left they soon wear flat and decrease the original shrinkage.

Accurate measurements of tires after they have been in service for some time, especially when less than 2½ inches in thick-



ness, show that a rolling out or stretching of the tire occurs, and for reasonably heavy centers these figures would account more for loose tires than any permanent set in the driving-wheel center.

In Fig 8 is shown the exact caliper dimensions of the wheel centers and tires which were reported loose on Atlantic engines having about 104,000 pounds weight on drivers. These tires had been previously shimmed, and contained liners between the tire and center .068 inch on the left and .050 inch on the right for the entire circumference.

Fig. 9 shows diameter of tires 2⅛ inches thick, which had been removed from a similar engine. These dimensions appear to confirm the statement that considerable rolling out and stretching occurs when the tire becomes reduced in thickness , and it is especially noticeable that this rolling action of the wheel is most apparent on the outside of the tire where the wear of the rail would be the greatest.

SUBJECTS.

Committee—R. D. Smith, chairman; G. W. Wildin, C. H. Quereau.

COMMITTEE REPORTS, 1907 CONVENTION.

1. The comparative arrangement for coaling stations.
F. F. Hildreth, F. H. Clark, J. B. Barnes.
2. Submit a blank form for use at terminals to give history of the movement of every locomotive from the time it leaves its train until it takes its next train. Object: to secure closer co-operation between the mechanical and operating departments.
G. M. Basford, R. D. Smith, R. P. C. Sanderson.
3. What thickness of tires is the most practical for locomotive driving wheels—3 ins., 3½ ins. or 4 ins. thick? Why?
W. T. Fitzgerald, John Howard, H. F. Bentley.
4. Results of different valve gears on locomotives.
C. A. Seley, A. S. Vogt, G. H. Haselton, Robert Quayle.
5. Proper allowance for fitting axles and crank pins to driving wheel centers and method of registering the pressure.
S. W. Miller, L. R. Pomeroy, S. M. Dolan.
6. Pay for shop and roundhouse labor and comparative merits of day work, piece work, bonus or other systems.
David Van Alstyne, J. F. Deems, W. R. McKeen, Jr.
7.. The proper spacing of flues in high-pressure boilers.
Charles E. Fuller, H. J. Small, F. J. Cole.
8. Supervision in large locomotive repair shops.
G. W. Wildin, H. H. Vaughan, J. B. Kilpatrick.
9. Boiler shop area in square feet, per pit of erecting shop, including cranes, machine and tool equipment.
T. Rumney, A. C. Deverell. A. E. Manchester.

INDIVIDUAL PAPERS, 1907 CONVENTION.

1. Locomotive failures, records and results of keeping them.
Paper by W. E. Dunham.
2. Superheating and compounding from a standpoint of locomotive economy.
Paper by T. A. Foque.
3. Shop cost systems and effect of shop schedule on output and cost of locomotive repairs.
Paper by A. Lovell.
4. Causes for leaky flues.
Paper by M. E. Wells.

MECHANICAL STOKERS.

Committee—W. Garstang, chairman; D. F. Crawford, J. F. Walsh.

Since the last convention there has been little progress made in the development of the automatic stoker for locomotives, as in addition to continued trials of the stoker mentioned in the proceedings of the 1905 convention the committee has advice of trials of but one other stoker. This stoker had in connection with it apparatus for conveying the coal from the tender to the stoker hopper above the fire door. The types of locomotives, nature of service and kinds of coal used by the various railroads, make it very difficult, at the present time, to make any valuable comparisons of the performance of the various types of stokers.

THE MODERN LOCOMOTIVE INJECTOR.

(Individual Paper.)

BY MR. STRICKLAND L. KNEASS.

THE SUPPLY.

The water supply is forced through the narrow entrance to the combining tube of the injector by atmospheric pressure, the available head being the difference between the suction height at the water branch and the vacuum within the combining tube. It is necessary that this entrance area be small, so that the water shall have a high velocity during its time of contact with the steam, but the suction pipe and connections should be of ample size, or the resultant friction will reduce the effective head at the entrance to the combining tube. The pipe diameters recommended for various nominal sizes of injectors are given in the following table:

TABLE I.

Normal Size of Injector.	7	8	9	10	11	12
Iron (Inside)....	1½ ins.	2 ins.	2½ ins.	2½ ins.	3 ins.	3 ins.
Copper (Outside).	1¾ ins.	2¼ ins.	2¾ ins.	2¾ ins.	3¼ ins.	3¼ ins.

(Non-Lifting Injector may use one size smaller.)

The areas of the tank valve and connecting castings should be greater than given in Table I. The perforations of the straining plate should not exceed 3-32 in. diameter, and their total area should be three times that of the suction pipe; the tank should be frequently cleaned and kept free from ashes and coal.

The suction pipe should be short and direct, with easy bends, and preferably of copper. The injector should be placed at or about 6 ins. above the upper level of the water in the tank. The effect of increasing the height of lift is apparent from the following table:

TABLE II.

EFFECT OF HEIGHT OF LIFT.

Height of Lift.	Steam Pressure.	Water Supply.	Capacity in Percentage.
2 feet	200 pounds	75°	100%
6 feet	200 pounds	75°	95%
8 feet	200 pounds	75°	80%

The suction pipe, hose and connections should be absolutely tight under 30 lbs. pressure.

The effect of an increase of temperature of the water supply is to reduce the capacity. Given a normal temperature 65 deg. and height of lift of 2 ft., and the capacity as 100 per cent., increasing the temperature of the water supply to 85 deg. reduces the capacity to 89 per cent., even though the lift is unchanged. The following table shows the effect of temperature of water supply on the capacity at 200 lbs. boiler pressure:

TABLE III.

EFFECT OF TEMPERATURE OF WATER SUPPLY UPON CAPACITY, 200 POUNDS BOILER PRESSURE, 2-FOOT LIFT.

Water Supply	65°	75°	85°	95°	105°	115°	125°	135°
Capacity in Percentage.	100%	96%	89%	80%	72%	68%	67%	66%

The ratio at which the capacity is reduced is not in the same proportion above 105 deg. temperature of water supply as the internal conditions of the jet above that temperature are changed.

The condition of the steam supply is also of great importance; it should be dry and saturated, and conducted through pipe passages large enough to allow full boiler pressure at the steam nozzle of the injector. Wet steam tends to cut the valve seats and nozzles, superheated steam to reduce the mechanical efficiency and the capacity.

INJECTORS.

The action of the injector depends primarily upon the impact of a condensible gas upon its own liquid; the directing and receiving nozzles should be designed and constructed according to the curves that govern the flow under given conditions of velocity and pressure; owing to the high velocities of both the actuating gas and the resultant jet, departure from the correct contour causes rapid and unnecessary wear. The surfaces should be smooth and hard, the metal homogeneous, and without microscopic evidence of porosity, characteristic of all tertiary or quarternary alloys.

The essential characteristic of a boiler-feeding device is certainty of action, because the failure of a locomotive due to a defective injector, although serious enough in its consequences, cannot compare with the injury and loss of life which may result from an exposed crown sheet. Of secondary, but also of great importance from an economical point of view, are the range, efficiency, etc. These desirable points are emphasized under the headings: "Construction," "Performance of an Injector."

CONSTRUCTION.—The design of an injector should be simple and constructed with the fewest parts, as it is easier to understand and cheaper to repair, and the stock of renewal parts is reduced to the minimum.

It should contain a single-seated lever starting valve. Double steam seats are difficult to keep in line, leak more quickly and are expensive to repair.

All valve seats subject to pressure should be heavily constructed and easily removable.

The overflow valve should be self-opening. It should not be subject to the pressure of the boiler; it should open freely if the injector "flies off." The heater cock should be convenient of access. All parts should be perfectly interchangeable.

PERFORMANCE.—No hand adjustment of the water supply should be required to prevent wasting, for any change of boiler pressure. It should operate at 15 lbs. steam and give its heighest capacity at or above the working boiler pressure. The minimum capacity should be at least 50 per cent. of the maximum, for there are few cases where a continuous feed is not the most economical, both for fuel consumption, and for the life of flues. It should be able to feed continuously with either a light or heavy train.

It should re-start automatically, for the water supply is liable to be temporarily interrupted by the swash of low water in the tender or by accidental adjustment of the feed below the minimum capacity. In either case the injector should reprime automatically. Further, automatic re-starting renders the action positive when running at night or when the injector is placed outside of the cab.

It should be economical in the use of steam, so that when the locomotive is heavily loaded, starting the injector will not pull down the boiler pressure. Starting a No. 10 injector reduces the tractive power from 95 to 150 h.-p., depending upon the design of the injector, tubes and nozzles.

When the steam pressure is 200 lbs., the injector should operate positively with a water supply at a temperature of at least 100 deg.; a still higher limiting temperature is advantageous, if the performance of the injector is not sacrificed.

Comprised under both the above heads is the wear of the internal parts; at 200 lbs. pressure, the velocity of the steam at the smallest part of its nozzle is 1,500 feet per second, increasing to 2,800 ft. per second at the terminal flare and reaching 3,847 ft per second at the time of impact with the water.

The cutting action of silt or dirt in the water supply is proportional to the velocity of the carrying jet, just as is the case with a polishing or abrading wheel. If the tubes are correctly designed, the converging and diverging curves corresponding to the lateral contraction and expansion of the jet, the longest service will be given. But to reduce the cutting action, it is obviously advantageous to maintain as low a velocity in the delivery tube as is consistent with the ability to feed the boiler; this can only be obtained when the minimum weight of steam is used by the injector per gallon of water delivered, and the amount of steam used can be measured by the temperature of the feed entering the boiler compared with that of the water supply. The higher the temperature of the delivery, the greater the excess of steam used, and the higher the velocity of the jet and consequent cutting action.

A table giving the relation of delivery temperature to the velocity of the jet is given below:

TABLE IV.

VELOCITY OF JET IN DELIVERY TUBE, FOR TEMPERATURE OF BOILER FEED, STEAM PRESSURE 200 POUNDS, WATER SUPPLY 65°.

Temperature Boiler Feed.	Approxi'te Velocity. Ft. per Sec.	Ft. per Min.	Temperature Boiler Feed.	Approxi'te Velocity. Ft. per Sec.	Ft. per Min.
160	230	13,800	250	315	18,900
175	238	14,280	275	365	21,900
200	255	15,300	300	455	27,300
225	280	16,800	325	580	34,800

When it is remembered that the surface speed of a grinding wheel is only between 5,000 and 6,000 ft. per min., the enormous velocities noted in Table IV and the effect of abrasive foreign material in the water supply will be appreciated.

When the water supply contains lime-bearing salts, both the exterior and interior surfaces of the tubes become coated; however, if the tubes are continually submerged in cold water, the precipitation of scale is largely prevented. A properly designed non-lifting injector is very serviceable with water of this kind; during operation, water from the supply may be admitted directly to the overflow chamber and tubes; when shut off, closing the waste valve keeps the injector body flooded, condensing all leakage from the steam valve.

THE DELIVERY.

The delivery should be conducted through two check valves, the main check bolted or screwed to the boiler shell. This check is preferably supplied with a superimposed stop, to permit the complete withdrawal of the main check valve and its seat from the casing without reducing the pressure of the boiler. Secondly, a supplemental check, placed close to the injector. The reason for advocating a check valve in the pipe line is that with the present fixed standards of exterior dimensions of the injector and its branches, it is practically impossible to design a satisfactory valve at or near the delivery tube, and contained within the injector body, which will be convenient of access without breaking the delivery connection, or will be durable under high boiler pressures.

The delivery pipe need not be as large as the suction, as there is always ample forcing power in an injector to overcome a valve and pipe resistance of from 10 to 50 pounds counter-pressure. Where the water supply contains carbonate or sulphate of lime, it is advantageous to use a larger pipe, on account of the coating of scale which soon forms on its interior surface when the main check leaks.

WELDING LOCOMOTIVE FRAMES.

BY R. P. C. SANDERSON.

The first successful attempts to weld broken frames in place, that were given much publicity, were made on the Southern Pacific in California, following which the writer took up the idea and made many successful welds, using kerosene oil as fuel; gas can also be used very well. Each fracture requires its own detailed treatment; there can not be any text-book examples laid down for others to follow. There are, however, governing conditions that rule in every case that should be understood.

To get a welding heat quickly with the least possible wasting away or burning of the metal, the oil or gas flame must be regulated so that there is not quite enough air to give absolutely perfect combustion, to the end that there will be little or no free oxygen in the flame to oxidize the metal.

For the same reason the little furnace that must be built up and around the fracture to be welded should have only just space enough for the flame to whirl around the frame, give off its heat to the fire bricks and fire clay, which soak it up like a sponge soaks up water, without this flame being driven too hard against the metal, as this will cause wasting away. The inlet for the flame and its first contact with the metal should be at the back or unimportant part of the frame and not against a finished surface, that has been or must be machined, as the wasting away is greatest at first impact of the flame. There should be as little space between the metal to be heated and the furnace wall as will suffice, as the heating is done principally by the heat that has been soaked up by the bricks and is radiated back against the metal. Radiation loses force rapidly with increasing distance.

The outlet for the waste flame should be located where the man doing the job can watch the heat through it and see the weld, as a minute's extra heating is very wasteful.

No more of the frame should be heated than must be to get a good weld, seldom over 4 or 5 inches each side of the weld.

The furnace must be so built that a couple of quick blows of a sledge will knock it all down, clear out of the way, so that the smiths can sledge up the weld on the sides while yet at the serviceable heat. The pit can be partly full of water into which the red hot bricks fall.

A 4 by 5 frame can be brought to a welding heat in not to exceed twenty minutes, if the points just mentioned are thoughtfully observed.

When a weld is made in this manner the frame will of course be a trifle shorter and somewhat wasted away, which is objectionable. To avoid this it is best to jack the fracture apart and place between it ⅜ inch of good high-grade soft hammered iron, the irregularity of the fracture will usually keep the surface more or less apart, which has the advantage of allowing the heat to penetrate between the broken surfaces. The soft iron between the broken parts heats first and acts as a cement, welding more easily on the broken surfaces than they will to one another.

To get a perfect weld, a thirty-ton hydraulic jack should be in place before the heat is started, so that when the metal is at welding heat it can be pumped up and force the broken surfaces together at its full power. To prevent the frame bending under this pressure it must be counterbraced, which is usually easy to do. By jacking the fracture together in welding, the surface around the weld is bulged out a little all around and after the furnace is knocked down while the pressure of the jack is still on, the two smiths can hammer away at the surfaces of the weld, leaving enough to chip or file down to a fair bearing for shoes or wedges, etc.

It is best to make some centerpunch marks in the frame well away from the weld on either side; have a tram made to fit these punch marks, allowing just a little for shrinkage for the final cooling off. These punch marks must be well outside of the furnace and the tram made to straddle it, then the tram can be

held in place while the jacking is done and the foreman can see when the weld has been sufficiently crushed together.

With skill and thought many a broken frame can be welded in place in this manner and give satisfactory service afterwards, but, if the frame is too weak in design at the broken place, it needs strengthening or it will break again. We can not add metal by welding as described but must resort to some other method.

THERMIT WELDING.—Here is where the recently invented and developed process of Thermit welding comes to our assistance and this permits repairs to be made and reinforcement to be made on broken frames in cases that could not be handled in any other known way.

The Thermit process is not a welding process in any sense of the word, but is a foundry process—casting process. The blacksmith has little or nothing to do with it; as a general proposition he should be kept out of it, as his life's training, his prejudices and his interests must naturally be in an entirely different direction.

Perhaps a history of the writer's experiences in learning to use Thermit successfully will serve as a guide for others who have not tried it, or show those who have had ill success with it how they can reach success.

Profiting by the experience of a disappointed neighbor, we did not make any attempt to weld engine frames at first.

The first thing done was to make a few small casts of Thermit; study its temperature and action on small sections of iron and steel.

Following this we took some short broken sections of old frames and laid them in a mold on the foundry floor and attempted to mend the fractures by Thermit.

Following the usual prescription given us at that time by the manufacturers, the first cast was made and the result appeared to be a first-class job; however, bearing in mind the trouble our neighbors had had, the piece of metal was taken and put in a planer and sliced from end to end, exposing the core or center of the weld. One-half of this was polished on the emery wheel on the guide grinder, and this showed—while bright—that the molten steel from the Thermit had welded itself on to the partly fused stub ends of the old frame, but in cooling off had shrunk by natural contraction, leaving a number of cavities, like blow holes, in the center, which very materially weakened the section at that point.

It was found that this metal was exceedingly hard and brittle, while the rest of the frame was of the usual soft hammered wrought iron, consequently we had a hard, brittle, spongy knot in the middle of the bar of soft iron.

The other half of this sample was heated in the furnace and drawn out under the steam hammer. It drew down to about one-half of the original section and then broke in two, right through the old fracture and through the center of the Thermit. The fracture showed that the break had occurred through these shrinkage cavities or blow holes.

Study of the proposition indicated clearly that some method of forcing the broken fracture together, after the cast had been made, and during the process of cooling off, and while the metal was still at welding temperature, was necessary, to close up the spongy holes—in other words the shrinkage must be followed up in order to get solid metal. Another advantage of this would be that instead of the particles of the molten steel cooling off in the form they assume in a steel casting—in other words, in a crystallized condition—that this crushing together would in a measure produce a similar result to a subsequent forging process, in that it would knead or squeeze the congealing metal and make it more ductile.

To prove the correctness of this reasoning, a fresh sample was prepared and fresh cast was made with it in precisely similar manner to the first cast, but after pouring the cast the two ends of the frame were forced together with jacks a distance of a little over ⅛ of an inch.

The result justified our belief. The cavities were very much fewer and much smaller, and crushed together, so that they represented flaws or lines rather than holes. It was evident that the crushing together process had not been undertaken soon enough, or with sufficient pressure to properly weld up these shrinkage cavities. It was also noticeable on the fractures, after polishing, that there was rather a definite line of demarcation at the junction where the cast steel had burned on to the wrought iron, and in cutting it, it was noticed that when the tool went through the soft iron and came up against the hard Thermit there was a distinctly different resistance, indicating still a hard knot in the middle of the soft frame.

The other half of this section, after being sliced, was drawn out under the steam hammer at a higher temperature than the first cast, and drew down to less than one-third of the original section before fracture took place, and this again showed breakage through the shrinkage cracks of cavities.

It was evident that our processes were not right yet, and since Thermit steel by its own nature must necessarily be a more dense and harder metal than any wrought-iron or cast-steel frame could usually be, it becomes necessary to figure out some way in which the line of demarcation between the Thermit, which is manganese steel, and the wrought iron, forged or cast-steel frame could be obliterated and be made more gradual, otherwise cracks would be sure to finally come in these frames at the point where this sudden change of quality in the material existed.

After much thought we decided to drill the ends of the frames at the fractures, choosing the size of the drills used to suit the size of the section; thus, as it were, making a series of dovetails in the two ends of the fractured frame, into which the liquid Thermit could be poured and interlock even though the welding might not be perfect. It would also do away with the sharp distinction between the Thermit steel and the soft metal of the original frame.

A third sample was prepared along these lines, and in view of the necessity of forcing it together more than was previously done, the original fractures were separated by small pieces of soft iron about ⅜ inch. The cast was made, and as quickly after the heat and flame and burning slag would permit the sections were jacked together until they resumed the original length between previously located center marks, which meant that the Thermit metal had been compressed ⅜ of an inch after pouring.

This weld showed a very distinct advance over the others. The cuff around the weld was swelled out, due to the jacking process.

When this sample was examined it showed at the section that the junction between the Thermit steel and the original metal was less clearly defined; there were only a few small spots or specks which would indicate shrinkage cavities.

The other half of this section drew down to about one-fourth size without any fracture, except a few small ragged surface cracks at the corners, and we felt that we had succeeded in developing a process which we could rely on to give satisfactory results.

One thing which was noticeable at once in the last experiment, which we had not thought of before, was shown by the polished fracture; the Thermit had melted off the ends of the dovetails. The conclusion to be drawn from this was obvious; that with such an arrangement as high a temperature as we had been experimenting with, with pure Thermit, was not necessary, and if anything objectionable, so that we added to the following test a proportion of boiler punchings in the Thermit, thus cheapening the process, and as the intense temperature of the melted Thermit was partly used in melting this additional quantity of steel punchings the result was the temperature of the molten metal was reduced; the character of the Thermit metal after cooling off was different, in that it had not been so suddenly chilled and was less brittle, which was an additional advantage gained by this new method.

Feeling confident of practical success we then proceeded to weld broken frames, following the lines of these last experiments, and have been, with two exceptions, successful.

To help toward certainty in the weld we arranged the Thermit mold around the fracture with an opening in the bottom for a gas or oil flame and, just as if we were going to make a flame weld in place, the frame and inside of the mold were heated until brought up to a bright cherry red, after which the hole in the bottom of the mold was quickly closed and made secure with a dry sand plug luted in and backed with sand and the Thermit touched off.

By doing this the Thermit was not chilled by a mass of cold frame; it did not require to be robbed of so much of its heat to fuse the heavy frame ends and a larger proportion of punchings could be used successfully, thus greatly cheapening the work. This preheating of the mold is of great importance.

To reinforce a weak place the usual cuff that is cast around the weld can be extended or thickened, making the weak place stronger than before the break.

There are of course plenty of places about locomotive frames where fractures may occur where Thermit can not be used, on account of the cuff interfering with attachments, but in many such cases we have chipped off such portion of the cuff as interfered and let the balance of it go, in other cases the presence of the boiler mud-ring or other parts up against the frame prevented the use of Thermit. Of course, Thermit can not be successfully used at the frame splices and in a few other places, and where it is just as easy to make an ordinary weld by means of a small furnace built around the frame as it is to use Thermit the ordinary weld is preferable and cheaper.

SPECIAL VALVE GEARS FOR LOCOMOTIVES.

INDIVIDUAL PAPER BY MR. C. J. MELLIN.

Pursuant to the request of the Committee on Subjects to present a paper on special valve gears, as the Walschaert, Allfree, Young, etc., I beg to submit the following, based on the understanding that it includes only such gears as are applicable to locomotives.

As several gears in use on locomotives are derivations from others not suitable for locomotives, it may in a few cases be of advantage, however, to go back to the origin from which they are developed, and others referred to as comparisons in being applicable but do not possess sufficient advantages for acquiring any extended adoption.

GOOCH VALVE MOTION.

Among the latter class may be mentioned the Gooch, or stationary link motion, which might be said to be the opposite of Stephenson motion, in that the valve rod or link block is raised and lowered in reversing the engine, instead of the link in the latter. It is operated with two eccentrics set in the same relation to the crank as in Stephenson's gear, and the link is curved to a radius equal to the length of the valve rod or radius bar and turned with its convex side to the axle. This motion gives a constant lead and has otherwise no advantage over the Stephenson gear, except, possibly, that the link block and the radius bar are lighter to lift in reversing than the link; but it presents an objectionable feature in that the sweep of the radius bar in its raising and lowering is obstructed by the front driving axle when the main connection is made to the second or third pair of wheels, and is probably the principal reason why the Gooch gear has been in little use and is now practically abandoned altogether in locomotive service.

ALLAN VALVE MOTION.

The Allan motion may be said to be a combination of the Stephenson and Gooch gear, as the link and valve rod are both moved in opposite directions, so that the angularities and distances

in either direction are reduced to one-half of those in either of the other motions under comparison with an increase of lead amounting to about one-half of that obtained by the Stephenson gear in linking up the engine. For this reason the Allan gear has been the favorite valve motion in continental Europe for a generation or more.

With properly selected lengths of lifting arms of the reverse shaft the link is made straight instead of curved as in the previous cases, which, in manufacturing in former days, was of no little importance in its favor. The lifting arms are placed on opposite sides of the reversing shafts, which is necessitated by the required opposite vertical motion of the link and valve rod in changing the cut-off or reversing the engine and thereby practically balancing each other and holding the reversing shaft in an approximate equilibrium at any position of the reversing lever.

These are all properties of considerable advantage over either the Stephenson or Gooch gears.

Although the Allan motion is the most correct one in existence it has never gotten any foothold in America, probably for the reason that it has to some extent the same objectionable feature as the Gooch in regard to the front driving axle, which, however, is not serious, as the short vertical sweep of the valve rod admits of a bend or a yoke for straddling the axle. As this motion is located inside the frames and occupies about the same place and is of the same weight as the Stephenson gear, on modern engines it would be heavy and cumbersome to apply, so its introduction at this time is hardly to be looked for. These conditions have also made themselves manifest in Europe, and the Allan gear, in spite of its excellent qualities, is fast disappearing from modern locomotives, being displaced by the more advantageous construction and application of the Walschaert motion, which will be referred to later.

The Stephenson, Gooch and Allan motions can be classified as one system in that they are all based on the two eccentrics set in symmetrical relation to the line of motion, one governing the forward and the other the backward movement of the engine, differing principally only in the matter of lead. In the Gooch gear, with its constant lead, it makes little difference if the rods are crossed or open, but in the Allan and Stephenson it is important that the rods are always open so that there is no reduction of lead in linking up, as crossed rods will reduce the port opening at the earlier cut-off and cause an unfavorable wire-drawing of the steam.

HACKWORTH VALVE MOTION.

There are various kinds of valve motions that are driven with a single eccentric, among which the oldest probably is that of John Wesley Hackworth, which was designed sometime between 1840 and 1850, and while this type in its original form is not suitable for locomotives, it is referred to as the starting point for a number of modifications, of which a few will be presented, in the line of its evolution to fairly good valve motions for locomotives under various names of so-called "radial" gears.

In 1879 Mr. Joy applied this gear with a slight modification to a locomotive engine and it is therefore generally known as Joy's gear. It is largely used in Russia and to some extent in several other countries without having gained any predominating use over the Allan motion which, as said before, until a few years ago was the general favorite in continental Europe. The Joy gear is probably the highest development of the Hackworth motion adaptable to locomotives and gives a very good steam distribution when properly fitted up, but the effect on the movement of the valve by the vertical play of the main axle on a rough track is not entirely eliminated.

In this arrangement, as well as in the original, and in fact in all modifications of the Hackworth gear, the link block or combination lever fulcrum can be guided by a curved frame ("link" as it has been called on account of its similarity to the ordinary reversing links), or by a swinging link and arm of approximately the same length as the radius bar where such a construction is applicable.

No principle of valve motion has been so fascinating and subject to so many varieties of construction as that of Hackworth, and a score or more inventors have, with comparably small modifications, found them meritorious enough to connect them with their names.

WALSCHAERT MOTION.

The most suitable form of radial gear for locomotives is unquestionably the one invented by the Belgian engineer, Egide Walschaert, in 1844, and applied to locomotives a few years later, but it was not properly understood or appreciated during the first twenty years following its invention, and has ever since then made slow headway until a few years ago, when it took quite a sudden move forward and is at present the dominating valve gear throughout the continent of Europe, and is rapidly gaining ground in this country, where, only within the last two years, it has been applied to engines for regular road service, although it has been in use in sundry cases, principally small engines. This gear may be said to be based on a fundamental principle of its own, but has also been subject to a few modifications without any improvement over its original form.

The motion of the valve is derived from two sources, namely, the main crank by connection to the crosshead, and from an eccentric placed approximately at right angles to the main crank. The crosshead connection imparts the motion of lap and lead at the extremities of the stroke of the piston, at which moment the link is in its central position. Therefore in the midgear with the reverse lever in its center notch this will be all the motion imparted to the valve and the radius bar becomes stationary. The link is curved to a radius equal to the length of the radius bar. By moving the reverse lever forward the eccentric motion is brought into combination with the motion from the crosshead, producing a valve opening for the forward motion of the engine, and by moving the reverse lever backward the link block is brought to the opposite side of the link fulcrum, resulting in a valve opening governing the backward motion of the engine, in effect similar to that of the Stephenson motion. The action of this one eccentric is therefore the same as if it was two eccentrics, one for forward and one for backward motion, placed diametrically opposite each other, and the angle of advance in the Stephenson motion is taken care of by the main crank in the crosshead connection. The latter motion being constant, it follows that the lead remains constant at all points of cut-off.

The proportions of the various parts of the Walschaert gear cannot be determined experimentally, nor should any change in setting the valves be made unless the effect of the change is known in advance. It is therefore important that the different parts should be made and set correctly from the beginning and there will then be no need for changes when the original dimensions are maintained. The difference in this gear for outside and inside admission valves must be considered in setting the eccentric crank and as the forward motion of the engine should preferably be taken from the lower end of the link when the eccentric crank will *follow* the main crank for *inside* admission valve, and *lead* the main crank for *outside* admission valve. The connecting point of the radius bar to the combination lever is *above* that of the valve stem connection for *inside* admission and *below* the valve stem connection for *outside* admission valves. The desired maximum cut-off, lead and valve travel determines the size of the lap, and thereby the lap and lead motion are obtained by the corresponding proportioning of the combination lever.

GENERAL NOTES FOR ADJUSTING WALSCHAERT GEAR.

1. Ascertain by the following method the position of the eccentric crank: Mark the position of the link relative to its middle position on both of the dead centers of the main crank. If the position of the link is the same in both cases the eccentric crank position is correct, if not the eccentric crank should be shifted until this occurs or as near so as possible.

2. After the eccentric crank has been correctly set the eccentric rod should be lengthened or shortened as may be required to bring the link in its middle position so that the link block can be moved from its extreme forward to its extreme backward position without imparting any motion to the valve. It may be noted that the link position may be observed by the usual tram marks on the valve stem, or direct by marks on the link pin as may be found most convenient with the link block in full gear, preferably ahead.

3. The difference between the two positions of the valve on the forward and back centres of the engine is the lap and lead doubled; it is the same in any position of the link block and cannot be changed by changing the leverage relations of the combination lever.

4. The tram marks of the opening moments at both ends of the valve should be marked on the valve stem and the latter lengthened or shortened until equal leads at both ends are obtained.

5. Within certain limits this lengthening or shortening may be made on the radius bar, if it should prove more convenient, but it is desirable that its length should be so nearly equal to the radius of the link that no apparent change in the lead should occur in moving the link block as stated in note No. 2.

6. The lead may be increased by reducing the lap and the cut-off points will then be slightly advanced. Increasing the lap produces the opposite effect on the cut-off and reduces the lead the same amount. With good judgment these quantities may be varied to offset the irregularities inherent in transforming rotary into lineal motions.

7. The valve events are to a great extent dependent on the location of the suspension point of lifter of the rear end of the radius bar, when swinging lifter is used, which requires that this point should be properly laid out by careful plotting, or, if convenient, it is preferably determined by a model, as irregularities due to incorrect locus of this point cannot be corrected by the other parts of the gear without more or less distortion of same. When this point is so fixed that a change of same is impracticable it may be better, however, to modify other elements if thereby the motion in general can be improved.

The chief point of difference between the Walschaert and Stephenson gear when both are in proper condition is, as previously stated, that the former gives to the valve a constant lead at all cut-offs, whereas the latter produces an increase of lead by linking up the engine which becomes excessive at short cut-offs. This very point has been the subject for much controversy and has probably done more than anything else to retard the progress of the use of Walschaert gear; as it has been argued that in full gear, when the speed generally is slow only small lead is needed, but at higher speed more lead is required, which is accomplished by the Stephenson motion, though this admittedly becomes excessive at early cut-offs, causing considerable compression and preadmission detrimental both to maintenance and to smooth running, and, in fact, to some degree counteracts the work done by the steam on the driving side of the piston, which thereby also affects the speed of the engine.

It was gradually discovered that the required lead for short cut-off and high speed was of no practical detriment to the working of the engine in full gear as the preadmission at that point is disappearingly small. The proper amount of lead, however, is dependent somewhat on the service, and the port opening becomes larger with a larger lead, or, in other words, when all other conditions are equal in a Stephenson or Walschaert gear the openings differ by the same amount as the lead, so that 1-16 in. more lead gives 1-16 in. wider port opening; but it is hardly advisable to make this over ¼ in. or 5-16 in. as a maximum, as the advantage of any additional port opening by means of a larger lead is more than off-set by the increase in compression and preadmission the larger lead would bring about at early cut-offs, and would do no good in the later cut-offs even if it does not do any harm.

There is no fundamental reason that the Walschaert gear should produce any economy in steam consumption over the Stephenson motion when both are in the best condition, but an advantage in

this respect comes to the former by the fact that it remains in its good condition if once made so, from one shopping to another, and is therefore on an average more economical both in steam consumption and maintenance of the gear than the latter. The accessibility for attention is a great point of undisputed advantage of the Walschaert gear which is also highly appreciated by the enginemen and attendants.

It will be borne out in the course of time that the bracing between the frames permitted by the Walschaert gear will bring about a considerable reduction in the maintenance expenses by the less wear and tear this additional rigidity will impart to the entire engine.

HELMHOLTZ MODIFICATION.

Among the various modifications of the Walschaert gear the one made by Helmholtz is probably of some advantage. This modification consists in making the link straight and the radius bar is connected to the lifting link instead of the link block. The curving of the link is compensated for by the reversing shaft or lifting arm fulcrum being located in a given position above the link so that the locus of the suspension point of the lifting link forms an arc of a circle with its chord perpendicular to the center line of the radius bar in its center position. The radius of this arc bears the same relation to the length of the radius bar as the distance of the radius bar connection above the link block bears to the length of the lifting link, which results in that this connection is moving in an arc with a radius of the length of the radius bar and the same motion of the valve is obtained as in the direct Walschaert gear.

Two advantages may be claimed for this modification, of which one is the straight link being simpler to make than the curved one, and the other is that on large piston valve engines with inside admission the link fulcrum can be lowered by the amount the radius bar connection falls over the link block, whereby the eccentric connection rod can be brought closer to the center line of the axle with less length of link and eccentric throw. It has, however, the disadvantage that there is little choice in the location of the reversing shaft or lifting arm fulcrum, a proper position for which is hardly obtainable on all types of engines and admits of no other method or lifting the radius bar in linking up or reversing the engine.

ALLFREE-HUBBELL GEAR ATTACHMENT.

The Allfree contrivance is an attachment to the ordinary Stephenson motion by which the valve is given a symmetrically irregular motion, causing it to open and close quickly, and is of special importance at high speed and early cut-off. The effect of this movement is about the same as what would be accomplished with a valve with extraordinarily long valve travel, but with a somewhat delayed exhaust and compression. The general construction of this device consists in substituting for the knuckle pin joining the valve stem to the rocker arm a small crank shaft, to which crank the valve stem is connected and the shaft left free to revolve in the rocker arm bearing. To this shaft a pinion is keyed engaging a toothed wheel sector oscillating on the rocker shaft by means of a lever connection from the crosshead. This gives a composite motion to the valve; namely, one direct from the eccentrics and one from the crosshead transmitted by the rotation of the crank on the knuckle pin shaft in such a way that the two motions coincide at the opening and closing moments, but are in opposition at the extreme travel of the valve, when the latter is nearly at a standstill, while the main crank passes through a comparatively large angle with a uniformly open port, and the closing of the valve is rapidly accelerated in the same manner as the opening, causing a quick and sharp cut-off. The exhaust and compression are similarly affected by this alternating, accelerating, and retarding motion of the valve, delaying the exhaust and compression even at early cut-offs. The advantage is, as already stated, greatest at high speed when a relatively high average pressure is obtained, which again is dependent on the capacity of the boiler. It is quite complicated to attach, especially on certain types of engines when the driving wheels are straddled by the guide yoke and thereby limiting the space required for the rocker arms and bearings.

YOUNG VALVE ARRANGEMENT.

This gear consists chiefly in the application of the Corliss valves to the locomotive engine with one valve both for the steam inlet and the exhaust at each end of the cylinder. Each valve is provided with double admission and exhaust ports. The steam ports are practically opposite each other, and the relation of the edges of the ports in the valve to these ports corresponds to that of the valve edges to the steam ports of the ordinary slide valve, forming the steam laps, lead and exhaust laps or clearances as the case may be. The exhaust cavity is a passage diametrically through the valve of sufficient width on one side to combine both steam ports with the main exhaust port simultaneously during the exhaust period. At right angles to the exhaust passage is a similar but somewhat larger cavity which corresponds to the steam chest with transverse passages through the valve body alternating with the exhaust passages, and the lap and exhaust edges are surrounded by carefully fitted slats, both on sides and ends to prevent leakage.

The motion is transmitted through a pivoted wrist plate to the valve from an ordinary Stephenson valve motion. By means of pivoting the wrist plate on the arm of a bell crank whose other arm is connected with a union rod to a short arm on the reverse shaft, the wrist plate is raised and lowered by the motion of the reverse lever producing a moderate increase in lead, an earlier exhaust and later compression than the direct Stephenson motion produces in linking up the engine.

The main advantage of this valve is the quicker admission, closing and exhaust it accomplishes due to the double port openings, and the small resistance it offers to the valve motion, as compared with the slide valve, in being completely balanced. In common with the Allfree gear it gives a higher average pressure at high speeds than the ordinary valve. This gear, as well as in the previous case, involves additional complications over the ordinary gear, requiring special skill, both in its manufacture and adjustment, which to some extent counterbalances the above-named advantages.

There are a few more modifications of various kinds which have not reached any adoption beyond the experimental stage before they were dropped out of existence and they are not of sufficient importance to be taken into consideration in this paper, in which only the most suitable gears for locomotives have been selected, and it is hoped that the few points referred to will furnish material for a discussion of fuller description of results in service from which valuable conclusions may be drawn.

PERSONALS.

Mr. C. B. Cramer, master mechanic of the Southern Railway at Sheffield, Ala., has resigned.

Mr. W. F. Moran has been appointed master mechanic of the Southern Railway at Sheffield, Ala.

Mr. E. L. Burdick, master mechanic of the Wabash Railroad at Decatur, Ill., has been transferred to Bluffs, Ill.

Mr. J. B. Young has been appointed chemist of the Philadelphia & Reading Railroad, succeeding Mr. Robert Job, resigned.

Mr. G. P. Robinson has been appointed inspector of locomotive boilers by the State Board of Railroad Commissioners of New York.

Mr. D. C. Courtney has been appointed superintendent of motive power of the Coal & Coke Railway, with headquarters at Elkins, W. Va.

Mr. D. P. Morrison has been appointed electrical engineer of the Pittsburgh & Lake Erie Railroad, succeeding Mr. G. M. Campbell, resigned.

Mr. F. K. Kraemer has succeeded Mr. C. A. Braun as master mechanic of the St. Louis, Iron Mountain & Southern Railway shops at Baring Cross, Ark.

Mr. M. S. Curley has been appointed superintendent of motive power of the Sierre Railway Company of California, with headquarters at Jamestown, Cal.

Mr. C. E. Paul, foreman of the erecting department, has been made general foreman of the Tilton shops of the Wabash Railroad, succeeding Mr. E. M. Hughes, transferred.

Mr. H. C. Klesschas has left the service of the Buffalo, Rochester & Pittsburg Railway to become chief air-brake inspector of the Chicago, Rock Island & Pacific Railway.

Mr. J. H. Farmer has been appointed master mechanic of the Mexican Division of the Chicago, Rock Island & Pacific Railway at Dalhart, Tex., succeeding Mr. E. D. Andrews.

Mr. E. F. Tegtmeyer, foreman of the Fort Wayne, Ind., erecting shops of the Pennsylvania Lines West, has been appointed assistant superintendent of C., R. I. & P. shops at East Moline, Ill.

Mr. James Farrell, acting superintendent of motive power and machinery of the National Railroad of Mexico, has been appointed superintendent of motive power and machinery, with office at Laredo, Tex.

Mr. Joseph Chidley has been appointed master mechanic of the Lake Shore Division of the Lake Shore & Michigan Southern Railway, with headquarters at Collinwood, Ohio, vice Mr. S. K. Dickerson, promoted.

Mr. C. L. Bundy, general foreman of shops, Delaware, Lack-

awanna & Western Railroad, has resigned to accept a position as manager of the car department of the Hicks Locomotive & Car Works, Chicago.

Mr. G. M. Reynolds has been appointed master mechanic of the Alliance Division of the Chicago, Burlington & Quincy Railway, with headquarters at Alliance, Neb., vice Mr. E. W. Fitt, assigned to other duties.

Mr. Francs W. Webb, for many years chief mechanical engineer of the London & Northwestern Railway, and the designer of the Webb four-cylinder compound locomotive, died at Bournemouth, England, on June 4th.

Mr. E. D. Andrews, master mechanic of the Chicago, Rock Island & Pacific Railway at Dalhart, Tex., has been appointed to the new office of master mechanic of the Arkansas & Louisiana divisions, with office at Little Rock, Ark.

Mr. E. B. Thompson, master mechanic of the Chicago & Northwestern Railway shops in Winona, Minn., has been appointed second assistant superintendent of motive power for the entire system, with headquarters in Chicago.

Mr. S. K. Dickerson has been appointed assistant superintendent of motive power of the Lake Shore & Michigan Southern Railway, with headquarters at Cleveland, Ohio, vice Mr. L. G. Parish, resigned to accept service with the Michigan Central Railroad Company.

Mr. LeGrand Parish, formerly assistant superintendent of motive power of the Lake Shore & Michigan Southern Railway, has succeeded Mr. Bronner as superintendent of motive power and equipment of the Michigan Central Railroad, with headquarters at Detroit, Mich.

Mr. E. D. Bronner, superintendent of motive power and equipment of the Michigan Central Railroad, has been appointed superintendent of motive power of the Lake Shore & Michigan Southern Railway, with headquarters at Cleveland, Ohio, in place of Mr. Ball.

Mr. Herman L. Delo, assistant chief motive power clerk of the Pennsylvania Railroad at Altoona, and for 52 years in the company's service, has been retired on a pension. Mr. Delo enjoys the unique record of never having lost a day's pay during his long term of employment.

Mr. James H. Crawford, foreman of the machinery department of the Wabash Railroad at Peru, Ind., has been transferred as general foreman of the shops at Decatur, Ill. Mr. Crawford has been succeeded by Mr. Edward Schwartz, formerly assistant general foreman of the Erie shops at Huntington, Ind.

Mr. H. F. Ball has resigned as superintendent of motive power of the Lake Shore & Michigan Southern Railway to accept a position with the American Locomotive Company as vice-president in charge of the automobile department. Mr. Ball has been with the Lake Shore & Michigan Southern Railway since 1890, and has been superintendent of motive power since February, 1902.

BOOKS.

The Railroad Manual Appendix and Diary. Sixth Annual Number. 283 pages. Published by Poor's Railroad Manual Co., 68 William St., New York.

This book contains complete information concerning railroad bonds and stocks for the use of bankers, investors, trust institutions and railroad officials. This edition contains several new features not given in previous issues, including the statistics of steam and street railways in the U. S. and a table of gross earnings by months for leading roads from 1900 to 1905.

The Car Builders' Dictionary, 1906. An illustrated vocabulary of terms which designate American railroad cars, their parts, attachments and details of construction. With definitions and illustrations of typical British practice in car construction. Compiled for the Master Car Builders' Association by Rodney Hitt, under the supervision of the following committee: C. A. Seley, H. F. Ball and J. E. Muhlfeld. Published by the *Railroad Gazette*, 83 Fulton Street, New York. Price, $6.00.

This is the fourth revised edition of the Car Builders' Dictionary since its first publication in 1879. The first edition was seven years in preparation, and five years after it was published it was necessary to revise it for the first time. The second revision was made in 1895, and eight years later the third revision was issued in 1903. During the last three years changes in the design and construction of cars has been even greater and of a more radical nature than during any of the periods intervening between the previous revisions. This is particularly so in respect to the wide use of steel for freight cars and the beginning of its general use for passenger cars. Steel cars of both kinds, and in a large variety, are included in this edition. A comparison of the pages of this and the 1903 edition will show that nearly half of the former engravings have been replaced by illustrations of new and improved devices, and that nearly 200 pages of illustrations have been added, giving a total number of illustrations in this edition of 6,344. The general arrangement, with some minor changes which it seemed proper to make, has been preserved. In view of the early publication of the Locomotive Dictionary, along similar lines, all references to devices and parts of devices belonging directly to the locomotive or tender have been eliminated, and considerable matter in reference to typical British cars has been added in this edition, which will give a good general idea of the dimensions and principal constructive features of the standard designs of cars used in Great Britain. The revision of the definitions has been made with a view of eliminating superfluous and obsolete matter and changing the wording of the definition of such terms as has gradually taken on a new meaning, and the addition of others which have come into general use during the past few years. Our readers who are familiar with the earlier editions will no doubt lose no time in securing copies of this revision, which brings the matter of car construction strictly up to date. To those who do not know the book it is only necessary to say that it affords a liberal education in the subject of modern car construction and the standards of the M. C. B. Association. Only the best and approved practice is included, and that is shown to the fullest extent.

CATALOGS.

IN WRITING FOR THESE CATALOGS PLEASE MENTION THIS PAPER.

DIRECT CURRENT GENERATORS.—The Fort Wayne Electrical Works, Fort Wayne, Ind., is issuing a bulletin descriptive of a direct connected direct current type of generator for power and lighting. This generator is carefully described in detail, the description being supplemented by illustrations of important parts.

BOOK OF BABBITT METALS.—The More-Jones Brass & Metal Company, St. Louis, is issuing a small catalog, showing its large variety of special grades of babbitt and anti-friction metals for different kinds and conditions of bearings. Each metal has a separate paragraph stating the uses for which it is specially adapted. Prices are given.

OIL ENGINES.—The DeLaVergne Machine Company, 138th Street, New York, is issuing an attractive catalog thoroughly describing and illustrating the Hornsby-Akroyd oil engine, which is constructed in practically any size desired. The catalog illustrates and briefly describes a large number of recent interesting applications, including several which drive the dynamos for furnishing the light for government lighthouses. The engine is shown in portable forms driving air compressors, dynamos, etc.

ELECTRIC APPARATUS.—The Emerson Electric Mfg. Company, St. Louis, is issuing a number of new bulletins briefly describing several new designs of electric machinery. One of these is a small type of motor driven air pump suitable for small users of compressed air. Another one shows small bi-polar enclosed motors with capacities of from 1-20 to 1-5 h.-p. These are also shown arranged with a worm gear speed reduction device. Direct current motors are also shown in small sizes with a worm gear speed reduction device.

SECOND-HAND METAL WORKING MACHINERY.—The Niles-Bement-Pond Company, 111 Broadway, New York, is issuing list No. 12 of second-hand metal working machinery, which includes 60 pages giving a brief description of the 300 different machines which they have on hand and are offering for sale. These machines are in many cases practically as good as new.

ELECTRIC-AIR ROCK DRILLS.—The Ingersoll-Rand Company, 11 Broadway, New York, is issuing an illustrated catalog descriptive of a new type of rock drill which has recently been perfected. This consists of an air drill in its simplest form, without valves, which is operated through two hose connections from a simple air compressor direct connected to an electric motor. Each set is mounted on a small car to run upon the mine tracks. Cable connections are carried to the motor, and the drill is operated directly by the compressor through the short hose connection. The catalog illustrates and describes this apparatus very completely.

INCANDESCENT MANTLE LAMPS FOR PINTSCH GAS.—The Safety Car Heating and Lighting Company, 160 Broadway, New York, has recently issued a catalog of standard size which shows a large number of illustrations and drawings, including numbered and named parts of a wide variety of styles for incandescent mantle lamps for passenger car lighting with Pintsch gas. These are shown with side brackets for single lights and with the center brackets for any desirable number of lights, arranged either for gas exclusively or in connection with electric light fixtures. It is stated that these mantels will give from 10 to 12 weeks' service and that they increase the candle power of the Pintsch gas more than three times.

G. E. ELECTRICAL APPARATUS.—The General Electric Company has recently issued a number of bulletins descriptive of the latest development and newest designs of different electrical apparatus. One of these illustrates and describes completely the G. E. 87 railway motor, which embodies the latest improvements in railway motor design. Another bulletin treats in a similar manner the direct current Curtis steam turbine generator sets of the horizontal type. These are made in sizes from 15 k.w. to 300 k.w., and can be operated either condensing or non-condensing. Other bulletins describes motor driven air compressors, type H subway transformers and small polyphase motors.

STEAM HEATING.—The Safety Car Heating and Lighting Company, 160 Broadway, is issuing a standard size catalog which includes a number of large plates illustrating the heating system for passenger cars, using either steam direct or the "standard system," which is a steam heating system in connection with the Baker heating system, the latter being installed in its usual manner, and the heating of the water and its circulation obtained by means of steam jackets placed at several points in the circuit; these jackets are heated by steam from the locomotive. Both of these systems are very completely described and illustrated, and the catalog includes illustrations of a large number of supplies used in connection with steam car heating.

RECORDS OF RECENT CONSTRUCTION, NOS. 56 AND 57.—The Baldwin Locomotive Works has recently issued the two last numbers of the "Record of Recent Construction." No. 56 is entitled the "Atchison, Topeka and Santa Fe Railway System," and confines itself exclusively to the illustrating and describing of locomotives on this system in an historical manner, showing the progress from the small early engines to the latest freight, passenger and switching locomotives. The record of the Scott special, which covered 2,265 miles in less than 45 hours actual time, with a train weighing 170 tons behind the engine, is given very completely, including reference to the illustrations of the locomotives used on each section. No. 57 is entitled "Common Standard Locomotives of the Associated Lines," and illustrates and describes in detail the different standard locomotives and parts adopted last year by the Harriman Lines, which were shown very completely in the AMERICAN ENGINEER. The locomotives are illustrated and much interesting matter concerning them is included in the pamphlet.

NOTES.

S. SEVERANCE MANUFACTURING COMPANY.—In the advertisement of this company, appearing on our front cover, the name of Mr. H. C. McNair as northwestern agent, was inserted by mistake in our July issue.

CHICAGO CAR HEATING COMPANY.—This company opened an eastern office at 170 Broadway, New York City, on July 1st. Messrs. F. F. Coggin and B. A. Keeler have been placed in charge of this office.

NEW SHOPS.—The Cincinnati Milling Machine Company, Triumph Electric Company, Cincinnati Planer Company and the Bickford Drill & Tool Company have jointly purchased a plot of about 100 acres of land at Oakland, Ohio, a suburb of Cincinnati, where it is expected they will erect new and larger shops the first of next year.

DAYTON PNEUMATIC TOOL COMPANY.—The recent report to the effect that the plant of the Dayton Pneumatic Tool Company, at Dayton, Ohio, had been destroyed by fire was an error. We are advised that the fire caused but small damage, which was quickly repaired, and that the plant resumed operation with a full force with only three days' delay.

CROCKER-WHEELER COMPANY.—The San Francisco agent of this company writes that while affairs are still in a very unsettled state and that he is not absolutely sure whether the number will be changed in from six months to a year, he considers that their office is located at 206 First Street, and that that address will be used until further announcement.

PAINT SHOP DRYING APPARATUS.—The new paint shop of the New York, Ontario & Western R. R. Co., Middletown, N. Y., is to be provided with a heating and paint drying apparatus consisting of fan, heater and distributing system, to be furnished by the B. F. Sturtevant Co., of Boston, Mass. Experience with this type of installation in other shops has shown a very material reduction in the time required to dry off cars after painting.

ALLIS-CHALMERS COMPANY.—The Allis-Chalmers Company of Milwaukee, who recently acquired exclusive rights to build and sell the Christensen air brakes, is busily engaged in organizing a new department for the extensive manufacture of this well-known device. These brakes will be manufactured in Milwaukee by the new department under the managership of Mr. J. H. Denton, who will be surrounded by a staff of men specially trained in this branch of work.

NILES-BEMENT-POND CO., BOSTON OFFICE.—The Boston offices of Niles-Bement-Pond Company and Pratt & Whitney Company have been removed from Pearl Street to more spacious and handsomely furnished quarters on the eighth floor of the Oliver Building, corner of Milk and Oliver Streets. The policy of these companies is to dispense with showrooms, the variety of both heavy and light machine tools and cranes built by their several works being too great to permit of exhibition.

NEWTON MACHINE TOOL WORKS.—The death of Mr. Charles C. Newton, founder and president of the Newton Machine Tool Works of Philadelphia, which was announced in our last issue, made it necessary to elect new officers of that company. The following men, who have been closely associated with Mr. Newton for many years, have been chosen: President, Mr. Harry W. Champion; treasurer, Mr. William M. Graham, and secretary, Mr. Ellis J. Hannum.

BARRETT JACKS IN NEW YORK CITY.—The Duff Manufacturing Company, of Allegheny, Pa., has opened an office in the Havemeyer Building at 26 Cortlandt Street, New York City, and have leased a warehouse within easy reach of this office where a complete line of Barrett and Duff roller bearing jacks will be kept in stock. Mr. Geo. A. Edgin is in charge of this office, and it is stated that patrons of this company in the vicinity of New York City will find it more convenient to send their orders and inquiries direct to this new office, which is now in a position to ship promptly.

EXHIBIT OF THE RIVERSIDE METAL COMPANY.—This company had a very interesting and complete exhibit of its product at the Atlantic City conventions, where were shown a full line of manufactured and ingot metals in phosphor bronze, German silver and other compositions of copper. These metals were exhibited in all shapes and forms, from the raw material to the finished product, in sheets, rods, wire, tubing, rope and castings, as well as passenger car fittings in white metal. This company has recently made a considerable addition to its plant and is in a position to handle large orders with reasonable notice.